

Executive Summary

For the 2017-2019 reporting period, the Lower Fraser Valley Air Zone is assigned orange management level for fine particulate matter and orange management level for ozone.

Introduction

This is the seventh annual quality report for the Lower Fraser Valley (LFV) Air Zone. Annual air zone reporting is a commitment under the national Air Quality Management System (AQMS). This report describes achievement of the Canadian Ambient Air Quality Standards (CAAQS) for ground-level ozone (O_3) and fine particulate matter ($PM_{2.5}$), the associated management levels and recent actions to improve air quality. A province-wide summary can be found at:

<http://www.env.gov.bc.ca/soe/indicators/air/>.

Background

The AQMS is the national approach to managing air quality in Canada. Under the AQMS, the CAAQS are developed to drive action to protect human health and the environment. Air zones are areas that exhibit similar air quality characteristics, issues and trends, and that form the basis for monitoring, reporting

and taking action on air quality. The Lower Fraser Valley (LFV) Air Zone (Figure 1) is one of seven broad air zones across B.C. Under the AQMS, progressively more rigorous actions are expected as air quality approaches or exceeds the CAAQS. The level of action is guided by the Air Zone Management Framework outlined in the AQMS management levels and objectives in Table 1.



Figure 1. Lower Fraser Valley Air Zone.

Table 1. AQMS management levels and objectives for $PM_{2.5}$ and ozone based on 2015 CAAQS.

Management Level	Objectives	Ozone	$PM_{2.5}$	
		8-hour (ppb)	Annual ($\mu\text{g}/\text{m}^3$)	24-hour ($\mu\text{g}/\text{m}^3$)
Red	Achieve CAAQS	>63	>10.0	>28
Orange	Prevent CAAQS Exceedance	>56 and \leq 63	>6.4 and \leq 10.0	>19 and \leq 28
Yellow	Prevent Air Quality Deterioration	>50 and \leq 56	>4.0 and \leq 6.4	>10 and \leq 19
Green	Keep Clean Areas Clean	\leq 50	\leq 4.0	\leq 10

Ozone Levels

Ozone measurements in the LFV Air Zone are summarized in Figure 2. Concentrations ranged from 36 parts per billion (ppb) in downtown Vancouver to 66 ppb in Mission.¹ Data from North Vancouver-2nd Narrows is excluded due to a major construction affecting measurements. Impact from the 2017 and 2018 wildfires resulted in elevated ozone readings that exceeded the national standard at Mission, Hope, and Maple Ridge. When adjusted following the methodology for transboundary flow/exceptional events (TF/EE), all LFV sites achieved the national standard of 63 ppb.

Over the reporting period from 2012 to 2019, Hope, Chilliwack, Abbotsford-Mill Lake, Port Moody and Burnaby South recorded their highest ozone levels in 2017-2019 from the influence of wildfires (Figure 3).

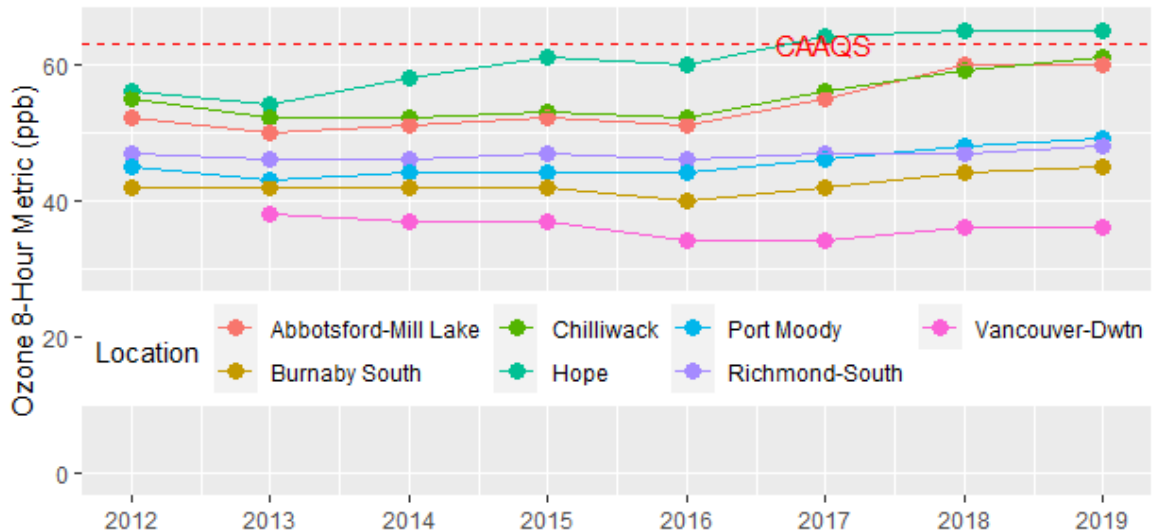
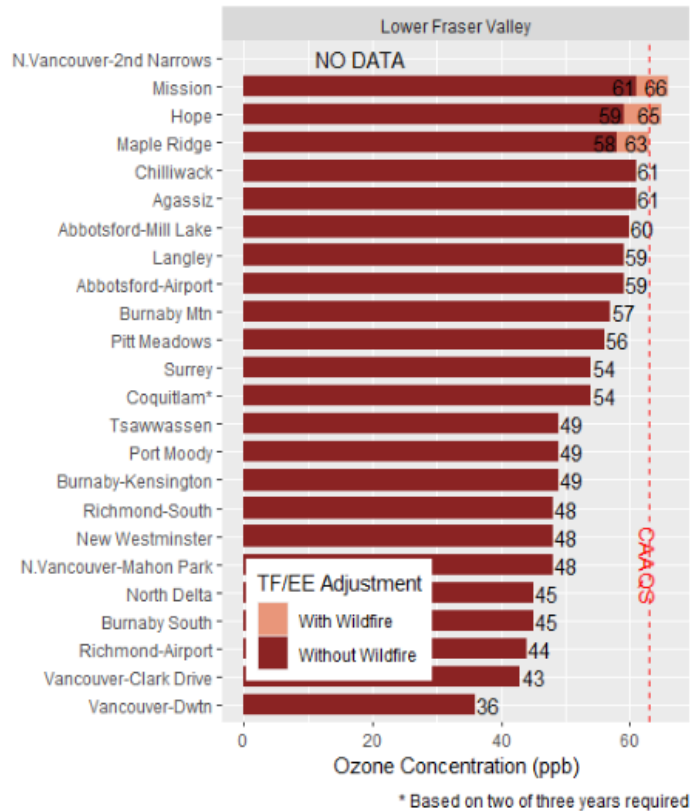


Figure 3. Trends in ozone metric (2012-2019), based on annual 4th highest daily 8-hour maximums over three consecutive years. Red dashed line identifies the 2015 CAAQS level of 63 ppb. The figure has not been adjusted for wildfire influence.

¹ Ozone 8-hour metric are based on the 4th highest daily 8-hour maximum, averaged over three years (2017-2019).

PM_{2.5} Levels

PM_{2.5} refers to inhalable particles that are smaller than 2.5 microns (µm) in diameter. All PM_{2.5} measurements in this reporting period are based on instruments certified under the US-EPA Federal Equivalent Method (FEM). PM_{2.5} annual metrics are based on the annual average of 24-hour values, averaged over three years (2017-2019).

Daily concentrations based on the 24-hour metric² (upper plot) ranged from 19 to 45 µg/m³. Data from North Vancouver 2nd Narrows are excluded due to a major construction affecting measurements. The national 24-hour standard of 28 µg/m³ is exceeded in 11 of the 21 stations. Adjusted for wildfire following the methodology for transboundary flow/exceptional events (TF/EE) adjustments, all LFV sites are well below the national standard.

Annual concentrations based on the annual metric³ (lower plot) ranged from 4.8 to 8.2 µg/m³. All monitoring sites achieved the national annual standard of 10 µg/m³ even on measurements influenced by wildfire smoke.

Trends in annual mean concentrations between 2012 and 2019 are shown in Figure 5 for a subset of LFV sites. Five of the eight sites shown in Figure 5 recorded their highest annual average PM_{2.5} concentration in 2017 or 2018. All eight sites recorded their highest daily concentrations in 2017 or 2018 (not shown). Smoke from wildfires within and outside of the air zone had a major influence on PM_{2.5} levels in 2017 and 2018 (see Appendix II for more information).

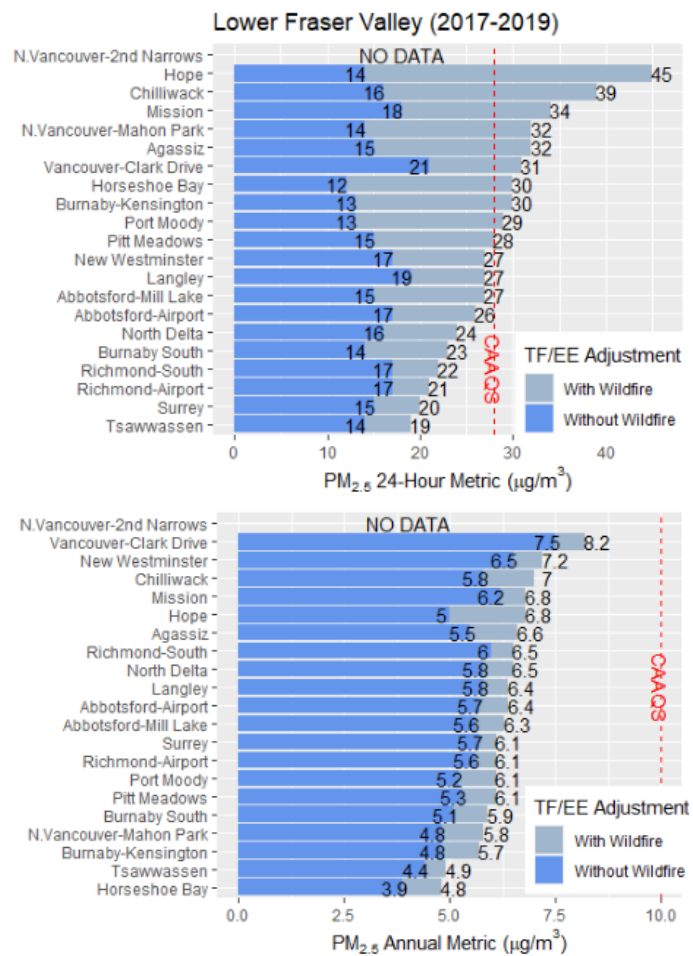


Figure 4. PM_{2.5} concentrations in the LFV Air Zone. Upper plot based on 24-hour metric (annual 98th percentile, averaged over 2017-2019). Lower plot based on annual metric (averaged over 2017-2019). The red dashed lines identify CAAQS of 28 µg/m³ (upper plot) and 10 µg/m³ (lower plot).

² PM_{2.5} 24-hour metrics are based on the annual 98th percentile of the 24-hour value, averaged over three years (2017-2019).

³ PM_{2.5} annual metrics are based on the annual average of 24-hour values, averaged over three years (2017-2019).

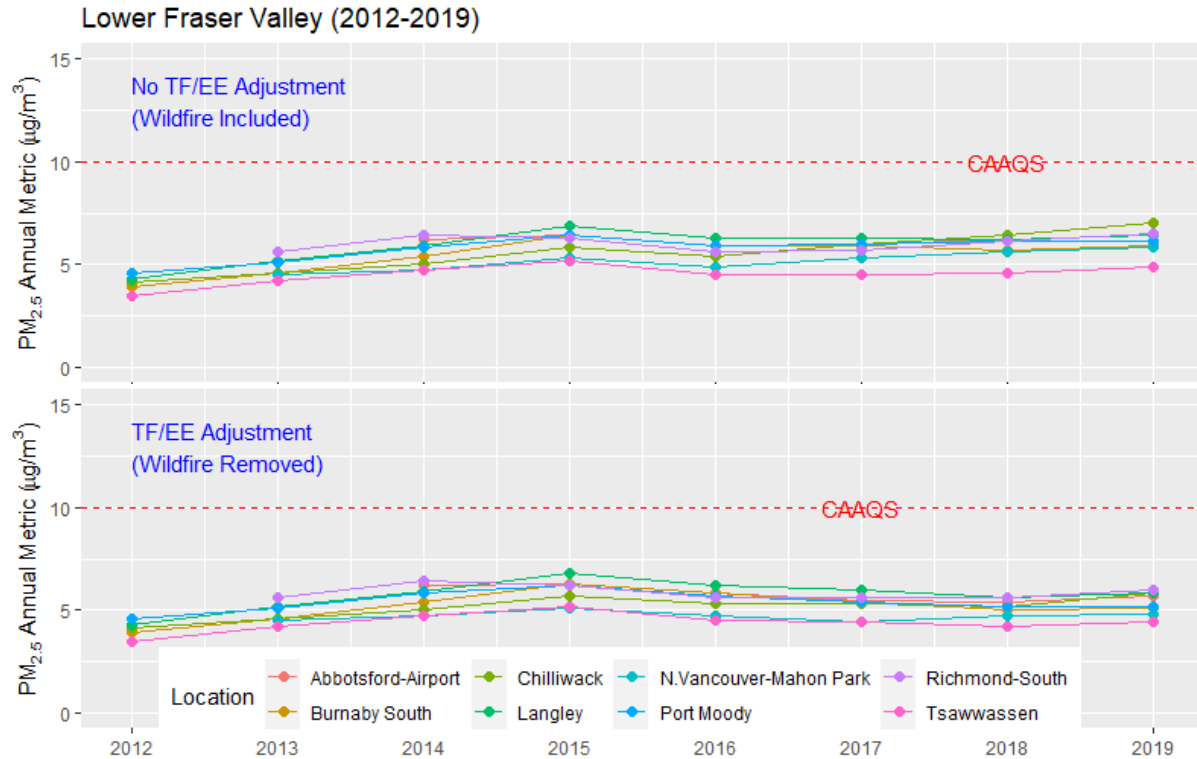


Figure 5. Annual trends in PM_{2.5} concentrations (2009-2018), based on annual mean concentrations over three consecutive years. The CAAQS value of 10 µg/m³ is shown by the dashed line. PM_{2.5} measurements prior to 2011 are reported at 25°C and 1 atm.

Air Zone Management Levels

Air zone management levels are assigned based on the highest concentrations within an air zone, excluding contributions from transboundary flows and exceptional events (TF/EE) such as wildfires, and preferentially based on those sites with three complete years of data. TF/EE influences are removed so that long-term management strategies are not developed based on events that are beyond local or provincial control.

Across B.C., wildfires are the primary contributor to TF/EE. The methodology for identifying wildfire-influenced data is provided in Appendix I and excluded data are summarized in Appendix II. Both the summers of 2017 and 2018 were characterized by hot, dry conditions that burned an unprecedented 1.2 and 1.35 million hectares of land in B.C., respectively. These fires created smoky conditions and periods of degraded air quality in several communities across the air zone.

Table 2 summarizes ozone concentrations as measured and after TF/EE influences have been considered. The LFV Air Zone is assigned an “orange” management level on the basis of ozone concentrations in sites in the eastern and central Fraser Valley, such as Agassiz, Chilliwack, and Mission. This highlights a need for actions to prevent future exceedances of the ozone CAAQS in the air zone.

Table 2. Summary of ozone metrics and air zone management levels for the LFV Air Zone (based on 2017-2019 data).

Location	No. Valid Years	Ozone 8-Hour Metric (4 th Highest Daily 8-hour Maximums, ppb)		Air Zone Management Level for Ozone
		As Measured	TF/EE Adjusted	
Abbotsford-Airport	3	59	59	Goal: Preventing CAAQS Exceedance
Abbotsford-Mill Lake	3	60	60	
Agassiz	3	61	61	
Burnaby-Mtn	3	57	57	
Burnaby-South	3	45	45	
Burnaby-Kensington	3	49	49	
Chilliwack	3	61	61	
Coquitlam	2	54	54	
Hope	3	65	59	
Langley	3	59	59	
Maple Ridge	3	63	58	
Mission	3	66	61	
N. Vancouver-2nd Narrows	Data excluded due to localized influence			
N. Vancouver-Mahon Park	3	48	48	
New Westminster	3	48	48	
North Delta	3	45	45	
Pitt Meadows	3	56	56	
Port Moody	3	49	49	
Richmond South	3	48	48	
Richmond-Airport	3	44	44	
Surrey	3	54	54	
Tsawwassen	3	49	49	
Vancouver-Clark Dr.	3	43	43	
Vancouver-Dwtn	3	36	36	

Table 3 summarizes PM_{2.5} concentrations as measured and with TF/EE influences removed for each monitoring site. Overall, the LFV Air Zone is assigned an “orange” management level, based on PM_{2.5} levels at Vancouver-Clark Drive. The “orange” management level indicates that PM_{2.5}-related actions should focus on actions to prevent CAAQS exceedance in the air zone. As the Vancouver-Clark-Drive monitoring station is located near a busy roadway, actions that target emissions from transportation-related activities may be particularly relevant.

Table 3. Summary of PM_{2.5} metrics and air zone management levels for the LFV Air Zone (based on 2017-2019 data).

Location	No. Valid Years	PM _{2.5} 24-Hour Metric (98 th Percentile, µg/m ³)		PM _{2.5} Annual Metric (Annual Average, µg/m ³)		Air Zone Management Level for PM _{2.5}
		As Measured	TF/EE Adjusted	As Measured	TF/EE Adjusted	
Abbotsford-Airport	3	26	17	6.4	5.7	Goal: Preventing CAAQS Exceedance
Abbotsford-Mill Lake	3	27	15	6.3	5.6	
Agassiz	3	32	15	6.6	5.5	
Burnaby-South	3	23	14	5.9	5.1	
Burnaby-Kensington	3	30	13	5.7	4.8	
Chilliwack	3	39	16	7.0	5.8	
Hope	3	45	14	6.8	5.0	
Horseshoe Bay	3	30	12	4.8	3.9	
Langley	3	27	19	6.4	5.8	
Mission	3	34	18	6.8	6.2	
New Westminster	3	27	17	7.2	6.5	
N. Vancouver-2nd Narrows	Data excluded due to localized influence					
N. Vancouver-Mahon Park	3	32	14	5.8	4.8	
North Delta	3	24	16	6.5	5.8	
Pitt Meadows	3	28	15	6.1	5.3	
Port Moody	3	29	13	6.1	5.2	
Richmond South	3	22	17	6.5	6.0	
Richmond-Airport	3	21	17	6.1	5.6	
Surrey	3	20	15	6.1	5.7	
Tsawwassen	3	19	14	4.9	4.4	
Vancouver-Clark Dr.	3	31	21	8.2	7.5	

Actions to Protect Air Quality

Through delegated authority under the *Environmental Management Act*, Metro Vancouver has responsibility for managing air emissions within its boundaries.

Metro Vancouver developed an *Integrated Air Quality Management and Greenhouse Gas Management Plan* in 2011.⁴ This plan sought to reduce levels of PM_{2.5}, ground-level ozone, and other priority pollutants to protect human health and the environment, improve visual air quality and minimize

⁴ <http://www.metrovancouver.org/services/air-quality/AirQualityPublications/IntegratedAirQualityGreenhouseGasManagementPlan-October2011.pdf>

contributions to climate change. Progress on the implementation of this plan can be found here: <http://www.metrovancouver.org/services/air-quality/action/iagggmp>.

Metro Vancouver is currently developing a *Clean Air Plan*, which is Metro Vancouver's management plan for the next 10 years. It includes 132 actions to improve regional air quality and reduce greenhouse gases. It includes sectoral targets to reduce emissions of NO_x, PM_{2.5} and diesel PM by between 10 and 50%. If all the actions in the Plan are implemented, the estimated health benefits could be as high as \$1 billion. For more information on *Clean Air Plan* development, see: <http://www.metrovancouver.org/services/air-quality/AirQualityPublications/CleanAirPlanBackgroundunderSeptember2019.pdf>.

The Fraser Valley Regional District (FVRD) is in the process of updating its Air Quality Management Plan that was first developed in 1998.⁵ This plan highlights several air quality issues, including ground-level ozone and PM_{2.5}. The FVRD has also reviewed options for developing alternatives to open burning, on-road and off-road engines, and emissions of ammonia. For more information, see: <https://www.fvrd.ca/EN/main/services/AirQualityandClimate.html>.

Regional air quality agencies including Metro Vancouver and the Fraser Valley Regional District developed a *Regional Ground-Level Ozone Strategy* in 2014.⁶ This strategy identifies goals and strategic policy direction for the LFV. The strategy is currently being updated.

A description of other activities underway in B.C. air zones can be found in the "Air Zone Management Response for British Columbia" (see: www.gov.bc.ca/bcairquality).

⁵ <http://www.fvrd.ca/assets/Services/Documents/FVRD%20AQManagementPlan.pdf>

⁶ <http://www.metrovancouver.org/services/air-quality/AirQualityPublications/RGLOS2014.pdf>

Appendix I – Approach to Identify Wildfire-influenced Data

Summertime air quality in British Columbia is periodically influenced by wildfire smoke – from local fires as well as long-range transport from outside of the province. The wildfire season in B.C. typically occurs between May and September, when warm and dry conditions prevail.

Different types of pollutants are emitted from wildfires. These include PM_{2.5} and gases such as nitrogen oxides and volatile organic compounds that can react in the atmosphere to form ground-level ozone and additional PM_{2.5}.

Given that smoke-affected areas may be extensive, and that smoke may linger for days before being fully dispersed from an airshed, the current analysis has focussed on those periods when wildfire smoke may have contributed to an exceedance of the CAAQS levels for ground-level ozone or PM_{2.5}. Criteria used to flag and evaluate wildfire-influenced data included the following:

- 24-hour PM_{2.5} concentrations in excess of the CAAQS level of 28 µg/m³ and/or 8-hour daily maximum ozone concentrations in excess of the CAAQS level of 63 ppb between May and September,
- Wildfires of interest identified based on data from the B.C. Wildfire Management Branch,
- Wildfire-related air quality advisories issued by Metro Vancouver during the period of interest,
- NASA satellite images showing smoke impacts over the region and
- Multiple monitoring sites in the area of concern showing similar air quality characteristics, suggesting a common regional source.

Wildfire-influenced data were excluded from the calculation of air zone management levels. Excluded data are as summarized in Appendix II.

Appendix II – Wildfire-influenced Data in the Lower Fraser Valley Air Zone (2017-2019)

Ozone and PM_{2.5} data from 2017-2019 for the Lower Fraser Valley Air Zone were evaluated based on the criteria set out in Appendix I for TF/EE influences. Various pieces of evidence were used to support identification of wildfire-influenced periods. These included the following:

- Wildfires of note – either due to size or proximity to populated areas – were identified by the BC Wildfire Service (see: <https://www2.gov.bc.ca/gov/content/safety/wildfire-status/about-bcws/wildfire-history/wildfire-season-summary>).
 - In contrast, 2017 (1.22 million hectares) and 2018 (1.35 million hectares) were record-breaking years in terms of area of land burned.
 - Wildfires of note in proximity to the Lower Fraser Valley Air Zone included the East Harrison Lake fire in 2017 and the Mount Hicks fire in 2018 (see Table II-1).
 - Of additional local interest was a bog fire in Richmond on Jul. 27, 2018 that burned up to five days.
- Smoke events during the summers of 2017 and 2018 were a result of local and more distant wildfires from elsewhere in B.C., Alberta, Washington and beyond.
- Days flagged as potentially wildfire-influenced generally coincided with or preceded smoke-related advisories issued by Metro Vancouver (see Table II-2 for ozone and Tables II-3 and II-4 for PM_{2.5}).
- While not all ozone events during the summer of 2017 and 2018 were determined to be a direct result of wildfire influence, all PM_{2.5} events coincided with periods of wildfire-smoke-related air quality advisories and as a result were considered to be wildfire-influenced.
- Satellite images during these periods provide additional supporting information on the spatial extent of wildfire smoke over the province, including the Lower Fraser Valley Air Zone, in 2017 and 2018. See Figures II-1 and II-2 for examples.
- Wildfire influences on specific ozone events are described further in Appendix III.

Table II-1. Summary of notable wildfires in the Lower Fraser Valley Air Zone between 2017-2019.⁷

Date Discovered	Size (ha)	Geographic Location	Description
2017-07-01	202	Harrison Lake East	30 km north of Harrison Hot Springs near the mouth of Big Silver Creek; Prompted evacuation alerts
2018-08-08	427	Mount Hicks	Located between Hope and Agassiz adjacent to Hwy 7

Table II-2. Days on which the 8-hour ozone concentrations exceeded the CAAQS level of 63 ppb (2017-2019) in the LFV Air Zone. Wildfire-influenced concentrations are highlighted in red. Rolling 8-hour average values are based on 1-hour concentrations rounded to the nearest integer.

Date	Hope			Mission			AQ Advisory in Effect
	8-Hr Daily Max O ₃ (ppb)	24-hr PM _{2.5} (µg/m ³)	Max T (°C)	8-Hr Daily Max O ₃ (ppb)	24-hr PM _{2.5} (µg/m ³)	Max T (°C)	
2017-07-05	67.5	8.3	29.3	60.9	10.1	28.2	None
2017-07-06	66.7	9.7	29.4	57.2	9.0	28.4	Yes (due to O ₃)
2017-08-03	78.3	89.3	31.5	61.1	69.9	31.1	Yes (due to PM _{2.5} from interior fires)
2017-08-07	72.0	73.9	29.3	70.5*	50.8	28.6	
2017-08-10	78.7	58.5	31.4	79.8*	52.7	30.4	Yes (due to PM _{2.5} from interior fires + O ₃)
2017-08-11	68.7	41.6	30.3	58.5	33.8	29.2	
2017-08-29	75.9	28.5	32.1	74.9*	23.7	31.3	
2018-07-16	71.3	11.5	31.6	57.3	9.7	31	None
2018-07-25	69.7	9.7	30.5	63.1	11.4	30.7	None
2018-07-26	69.8	13.5	30.5	63.0	10.0	30.4	None
2018-07-27	71.5	16.8	29.8	68.0	17.1	29.3	None
2018-07-28	70.9	14.6	30.1	57.9	11.4	29.0	O ₃ advisory
2018-07-29	72.6	16.1	32.6	79.3	17.3	32.5	O ₃ advisory
2018-07-30	78.0	18.4	34.2	81.5	23.1	33.8	PM _{2.5} and O ₃ advisory
2018-08-07	66.6	9.7	31.1	66.1	9.1	30.8	No advisory
2018-08-08	70.5	18.4	34.2	76.7	15.1	33.7	O ₃ advisory in FVRD
2018-08-09	65.6	25.3	33.2	77.1	11.5	n/a	PM and O ₃ advisory in FVRD
2018-08-21	62.6	82.1	30.8	67.4	83.7	31.2	PM and O ₃ advisory
2018-08-22	68.8	151.5	27.1	76.8	111	27.6	PM and O ₃ advisory

*Note: As the 4th highest daily 8-hour maximum O₃ concentration at Mission in 2017 was less than the standard level of 63 ppb, 2017 O₃ values from Mission were not evaluated for wildfire influence. However, given elevated O₃ and PM_{2.5} levels at both Mission and Hope on these days, it is likely that the Mission O₃ measurements were also influenced by wildfire smoke.

⁷ <https://www2.gov.bc.ca/gov/content/safety/wildfire-status/about-bcws/wildfire-history/wildfire-season-summary>

Table II-3. Wildfire-influenced PM_{2.5} data from 2017.

Location	Date	Daily Mean (µg/m ³)
Agassiz	2017-08-01	38.5
Chilliwack	2017-08-01	30.3
Hope	2017-08-01	62.6
Abbotsford-Airport	2017-08-02	48.5
Abbotsford-Mill Lake	2017-08-02	57.8
Agassiz	2017-08-02	98.6
Burnaby South	2017-08-02	54.4
Burnaby-Kensington	2017-08-02	56.3
Chilliwack	2017-08-02	88.2
Hope	2017-08-02	97.5
Horseshoe Bay	2017-08-02	53.3
Langley	2017-08-02	37.9
Mission	2017-08-02	68.1
N. Vancouver-2nd Narrows	2017-08-02	45.9
N. Vancouver-Mahon Park	2017-08-02	41
New Westminster	2017-08-02	44.4
North Delta	2017-08-02	37.1
Pitt Meadows	2017-08-02	41.4
Vancouver Clark Drive	2017-08-02	39.6
Abbotsford-Airport	2017-08-03	65.6
Abbotsford-Mill Lake	2017-08-03	55.5
Agassiz	2017-08-03	78.8
Burnaby South	2017-08-03	47.5
Burnaby-Kensington	2017-08-03	67.9
Chilliwack	2017-08-03	74.1
Hope	2017-08-03	89.3
Horseshoe Bay	2017-08-03	70.4
Langley	2017-08-03	49.3
Mission	2017-08-03	69.9
N. Vancouver-2nd Narrows	2017-08-03	70.2
N. Vancouver-Mahon Park	2017-08-03	66.1
New Westminster	2017-08-03	52.6
North Delta	2017-08-03	45.5
Pitt Meadows	2017-08-03	58.8
Port Moody	2017-08-03	74.7
Vancouver Clark Drive	2017-08-03	38.3
Abbotsford-Airport	2017-08-04	34.2
Abbotsford-Mill Lake	2017-08-04	40.5
Agassiz	2017-08-04	72
Burnaby South	2017-08-04	29.1
Burnaby-Kensington	2017-08-04	46.1
Chilliwack	2017-08-04	62.7
Hope	2017-08-04	79.4
Horseshoe Bay	2017-08-04	37.6
Langley	2017-08-04	31.9
Mission	2017-08-04	46.7

Location	Date	Daily Mean (µg/m ³)
N. Vancouver-2nd Narrows	2017-08-04	43.1
N. Vancouver-Mahon Park	2017-08-04	48.5
New Westminster	2017-08-04	30.2
North Delta	2017-08-04	30.4
Pitt Meadows	2017-08-04	39.3
Port Moody	2017-08-04	46.3
Vancouver Clark Drive	2017-08-04	31.2
Agassiz	2017-08-05	58.1
Burnaby-Kensington	2017-08-05	45.6
Chilliwack	2017-08-05	37.7
Hope	2017-08-05	80.1
Horseshoe Bay	2017-08-05	36.9
Mission	2017-08-05	32.4
N. Vancouver-2nd Narrows	2017-08-05	51.9
N. Vancouver-Mahon Park	2017-08-05	48.4
New Westminster	2017-08-05	32.1
Port Moody	2017-08-05	38
Abbotsford-Mill Lake	2017-08-06	30.9
Agassiz	2017-08-06	58.1
Burnaby South	2017-08-06	31.6
Burnaby-Kensington	2017-08-06	51.2
Chilliwack	2017-08-06	47.7
Hope	2017-08-06	86
Horseshoe Bay	2017-08-06	39.3
Langley	2017-08-06	29.8
Mission	2017-08-06	38.9
N. Vancouver-2nd Narrows	2017-08-06	47
N. Vancouver-Mahon Park	2017-08-06	47.2
New Westminster	2017-08-06	35.4
Pitt Meadows	2017-08-06	33.8
Port Moody	2017-08-06	46.8
Vancouver Clark Drive	2017-08-06	37.4
Abbotsford-Airport	2017-08-07	32
Abbotsford-Mill Lake	2017-08-07	37.3
Agassiz	2017-08-07	64.4
Burnaby South	2017-08-07	37.6
Burnaby-Kensington	2017-08-07	50
Chilliwack	2017-08-07	56.8
Hope	2017-08-07	73.9
Horseshoe Bay	2017-08-07	44.8
Langley	2017-08-07	37.1
Mission	2017-08-07	50.8
N. Vancouver-2nd Narrows	2017-08-07	53.1

Table II-3 (continued)

Location	Date	Daily Mean ($\mu\text{g}/\text{m}^3$)
N. Vancouver-Mahon Park	2017-08-07	53.2
New Westminster	2017-08-07	39.6
North Delta	2017-08-07	35.8
Pitt Meadows	2017-08-07	41
Port Moody	2017-08-07	52.4
Richmond South	2017-08-07	31.8
Richmond-Airport	2017-08-07	29.2
Tsawwassen	2017-08-07	29.3
Vancouver Clark Drive	2017-08-07	41.5
Abbotsford-Airport	2017-08-08	44
Abbotsford-Mill Lake	2017-08-08	48.4
Agassiz	2017-08-08	55.9
Burnaby South	2017-08-08	42.7
Burnaby-Kensington	2017-08-08	54.4
Chilliwack	2017-08-08	54
Hope	2017-08-08	55
Horseshoe Bay	2017-08-08	42.1
Langley	2017-08-08	43.2
Mission	2017-08-08	53
N. Vancouver-2nd Narrows	2017-08-08	55.7
N. Vancouver-Mahon Park	2017-08-08	58.4
New Westminster	2017-08-08	49
North Delta	2017-08-08	42.4
Pitt Meadows	2017-08-08	45.3
Port Moody	2017-08-08	56.2
Richmond South	2017-08-08	29.8
Tsawwassen	2017-08-08	29
Vancouver Clark Drive	2017-08-08	50.2
Abbotsford-Airport	2017-08-09	41.4
Abbotsford-Mill Lake	2017-08-09	45.8
Burnaby South	2017-08-09	44.8
Burnaby-Kensington	2017-08-09	56.3
Chilliwack	2017-08-09	51.9
Hope	2017-08-09	56
Horseshoe Bay	2017-08-09	50.7
Langley	2017-08-09	46.4
Mission	2017-08-09	57
N. Vancouver-2nd Narrows	2017-08-09	60
N. Vancouver-Mahon Park	2017-08-09	59.3
North Delta	2017-08-09	40.2
Pitt Meadows	2017-08-09	47.5
Port Moody	2017-08-09	57.8
Richmond South	2017-08-09	36.7
Richmond-Airport	2017-08-09	36.8
Tsawwassen	2017-08-09	33.6
Vancouver Clark Drive	2017-08-09	51.3

Location	Date	Daily Mean ($\mu\text{g}/\text{m}^3$)
Abbotsford-Airport	2017-08-10	38.2
Abbotsford-Mill Lake	2017-08-10	42.1
Burnaby South	2017-08-10	41.6
Burnaby-Kensington	2017-08-10	51.5
Chilliwack	2017-08-10	48.8
Hope	2017-08-10	58.5
Horseshoe Bay	2017-08-10	45.5
Langley	2017-08-10	42.3
Mission	2017-08-10	52.7
N. Vancouver-2nd Narrows	2017-08-10	57.4
N. Vancouver-Mahon Park	2017-08-10	56.3
New Westminster	2017-08-10	43.3
North Delta	2017-08-10	39.8
Pitt Meadows	2017-08-10	46.8
Port Moody	2017-08-10	54.9
Richmond South	2017-08-10	32.7
Richmond-Airport	2017-08-10	33.7
Tsawwassen	2017-08-10	29.7
Vancouver Clark Drive	2017-08-10	49.3
Agassiz	2017-08-11	46.3
Burnaby-Kensington	2017-08-11	29.9
Chilliwack	2017-08-11	31.3
Hope	2017-08-11	41.6
Horseshoe Bay	2017-08-11	29.2
Mission	2017-08-11	33.8
N. Vancouver-2nd Narrows	2017-08-11	37.1
N. Vancouver-Mahon Park	2017-08-11	32
Pitt Meadows	2017-08-11	29.7
Port Moody	2017-08-11	36.6
Agassiz	2017-08-29	31
Chilliwack	2017-08-29	28.2
Hope	2017-08-29	28.5
Hope	2017-09-04	29.3
Abbotsford-Airport	2017-09-05	33.1
Abbotsford-Mill Lake	2017-09-05	31.3
Agassiz	2017-09-05	41
Burnaby South	2017-09-05	29.2
Burnaby-Kensington	2017-09-05	35.7
Chilliwack	2017-09-05	40
Hope	2017-09-05	46.2
Mission	2017-09-05	34.3
N. Vancouver-2nd Narrows	2017-09-05	33.2
N. Vancouver-Mahon Park	2017-09-05	41.6
New Westminster	2017-09-05	30.3
North Delta	2017-09-05	29.7

Table II-3 (continued)

Location	Date	Daily Mean ($\mu\text{g}/\text{m}^3$)
Pitt Meadows	2017-09-05	32.1
Port Moody	2017-09-05	33
Vancouver Clark Drive	2017-09-05	30.2
Abbotsford-Airport	2017-09-06	32.4
Abbotsford-Mill Lake	2017-09-06	37
Agassiz	2017-09-06	56.9
Burnaby South	2017-09-06	31.1
Burnaby-Kensington	2017-09-06	44.3
Chilliwack	2017-09-06	57.4
Hope	2017-09-06	87.7
Horseshoe Bay	2017-09-06	43.9
Langley	2017-09-06	33.3
Mission	2017-09-06	47
N. Vancouver-2nd Narrows	2017-09-06	51
N. Vancouver-Mahon Park	2017-09-06	62
New Westminster	2017-09-06	43.6
North Delta	2017-09-06	34.4
Pitt Meadows	2017-09-06	40.2
Port Moody	2017-09-06	45.1
Surrey	2017-09-06	31.8
Vancouver Clark Drive	2017-09-06	37.5
Abbotsford-Mill Lake	2017-09-07	28.8
Agassiz	2017-09-07	46.6
Burnaby South	2017-09-07	31.9
Burnaby-Kensington	2017-09-07	39.4
Chilliwack	2017-09-07	42.8
Hope	2017-09-07	56.6
Horseshoe Bay	2017-09-07	39.5
Mission	2017-09-07	37.9
N. Vancouver-2nd Narrows	2017-09-07	42.3
N. Vancouver-Mahon Park	2017-09-07	41.9
New Westminster	2017-09-07	38.2
North Delta	2017-09-07	31.9
Pitt Meadows	2017-09-07	35.4
Port Moody	2017-09-07	41.5
Richmond-Airport	2017-09-07	28.6
Surrey	2017-09-07	29.1
Vancouver Clark Drive	2017-09-07	36.8

Table II-4. Wildfire-influenced PM_{2.5} data from 2018.

Location	Date	Daily Mean (µg/m ³)
Hope	2018-08-10	49.4
New Westminster	2018-08-10	31.6
Abbotsford-Airport	2018-08-13	29.3
Abbotsford-Mill Lake	2018-08-13	31
Agassiz	2018-08-13	54.4
Burnaby South	2018-08-13	40.8
Burnaby-Kensington	2018-08-13	44.1
Chilliwack	2018-08-13	52.1
Hope	2018-08-13	63.8
Horseshoe Bay	2018-08-13	41
Mission	2018-08-13	38.1
N. Vancouver-2nd Narrows	2018-08-13	38.3
N. Vancouver-Mahon Park	2018-08-13	40.3
New Westminster	2018-08-13	35.7
North Delta	2018-08-13	33.9
Pitt Meadows	2018-08-13	31.4
Port Moody	2018-08-13	38.6
Richmond South	2018-08-13	32.7
Richmond-Airport	2018-08-13	32.2
Surrey	2018-08-13	37.1
Tsawwassen	2018-08-13	30.3
Vancouver Clark Drive	2018-08-13	38.5
Abbotsford-Airport	2018-08-14	46.9
Abbotsford-Mill Lake	2018-08-14	46.2
Agassiz	2018-08-14	66.1
Burnaby South	2018-08-14	54.7
Burnaby-Kensington	2018-08-14	65.6
Chilliwack	2018-08-14	60.3
Hope	2018-08-14	65.3
Horseshoe Bay	2018-08-14	59.7
Langley	2018-08-14	44.4
Mission	2018-08-14	57.6
N. Vancouver-2nd Narrows	2018-08-14	65.9
N. Vancouver-Mahon Park	2018-08-14	63.8
New Westminster	2018-08-14	57
North Delta	2018-08-14	52.2
Pitt Meadows	2018-08-14	51.1
Port Moody	2018-08-14	69.6
Richmond South	2018-08-14	46.8
Richmond-Airport	2018-08-14	44.9
Surrey	2018-08-14	48.6
Tsawwassen	2018-08-14	34.5
Vancouver Clark Drive	2018-08-14	57.4
Abbotsford-Airport	2018-08-15	36.2
Abbotsford-Mill Lake	2018-08-15	35.3
Agassiz	2018-08-15	57.6
Burnaby South	2018-08-15	32.4
Burnaby-Kensington	2018-08-15	40.8
Chilliwack	2018-08-15	50.3
Hope	2018-08-15	71.2
Horseshoe Bay	2018-08-15	42.2
Langley	2018-08-15	33
Mission	2018-08-15	45

Location	Date	Daily Mean (µg/m ³)
N. Vancouver-2nd Narrows	2018-08-15	46.1
N. Vancouver-Mahon Park	2018-08-15	44
New Westminster	2018-08-15	40.2
North Delta	2018-08-15	36.3
Pitt Meadows	2018-08-15	37.8
Port Moody	2018-08-15	42.1
Surrey	2018-08-15	36.2
Vancouver Clark Drive	2018-08-15	39.4
Hope	2018-08-16	28.5
N. Vancouver-2nd Narrows	2018-08-16	28.9
Hope	2018-08-18	44
Abbotsford-Airport	2018-08-19	30.4
Abbotsford-Mill Lake	2018-08-19	39.3
Agassiz	2018-08-19	89.7
Burnaby-Kensington	2018-08-19	34.5
Chilliwack	2018-08-19	59.1
Hope	2018-08-19	240.8
Horseshoe Bay	2018-08-19	30.9
Mission	2018-08-19	43.9
N. Vancouver-2nd Narrows	2018-08-19	28.2
N. Vancouver-Mahon Park	2018-08-19	36.1
Pitt Meadows	2018-08-19	36.5
Port Moody	2018-08-19	32.4
Richmond South	2018-08-19	31.4
Richmond-Airport	2018-08-19	28.7
Tsawwassen	2018-08-19	28.3
Abbotsford-Airport	2018-08-20	76.9
Abbotsford-Mill Lake	2018-08-20	65.6
Burnaby South	2018-08-20	72.6
Burnaby-Kensington	2018-08-20	87
Chilliwack	2018-08-20	68
Hope	2018-08-20	70.5
Horseshoe Bay	2018-08-20	76
Langley	2018-08-20	59.3
Mission	2018-08-20	51
N. Vancouver-2nd Narrows	2018-08-20	101.6
N. Vancouver-Mahon Park	2018-08-20	94.7
New Westminster	2018-08-20	70.9
North Delta	2018-08-20	78.1
Pitt Meadows	2018-08-20	65.1
Port Moody	2018-08-20	84.6
Richmond South	2018-08-20	96.8
Richmond-Airport	2018-08-20	89.1
Surrey	2018-08-20	60.3
Tsawwassen	2018-08-20	92.4
Vancouver Clark Drive	2018-08-20	80.2
Abbotsford-Airport	2018-08-21	99.9
Abbotsford-Mill Lake	2018-08-21	90.7
Burnaby South	2018-08-21	74.5
Burnaby-Kensington	2018-08-21	59.6
Chilliwack	2018-08-21	78.6

Table II-4 (continued)

Location	Date	Daily Mean ($\mu\text{g}/\text{m}^3$)
Hope	2018-08-21	82.1
Horseshoe Bay	2018-08-21	55.4
Langley	2018-08-21	89.7
Mission	2018-08-21	83.7
N. Vancouver-2nd Narrows	2018-08-21	60.2
N. Vancouver-Mahon Park	2018-08-21	61.1
New Westminster	2018-08-21	75.7
North Delta	2018-08-21	91
Pitt Meadows	2018-08-21	69.4
Port Moody	2018-08-21	52.3
Richmond South	2018-08-21	99.3
Richmond-Airport	2018-08-21	91.5
Surrey	2018-08-21	100.8
Tsawwassen	2018-08-21	92.3
Vancouver Clark Drive	2018-08-21	74.8
Abbotsford-Airport	2018-08-22	126.5
Abbotsford-Mill Lake	2018-08-22	118.7
Agassiz	2018-08-22	117.4
Burnaby South	2018-08-22	112
Burnaby-Kensington	2018-08-22	98.9
Chilliwack	2018-08-22	118.7
Hope	2018-08-22	151.5
Horseshoe Bay	2018-08-22	96.2
Langley	2018-08-22	114.1
Mission	2018-08-22	111
N. Vancouver-2nd Narrows	2018-08-22	83.3
N. Vancouver-Mahon Park	2018-08-22	90
New Westminster	2018-08-22	128.1
North Delta	2018-08-22	125.4
Pitt Meadows	2018-08-22	106
Port Moody	2018-08-22	96.1
Richmond South	2018-08-22	123.1

Location	Date	Daily Mean ($\mu\text{g}/\text{m}^3$)
Richmond-Airport	2018-08-22	122.3
Surrey	2018-08-22	126
Tsawwassen	2018-08-22	124.7
Vancouver Clark Drive	2018-08-22	116.7
Abbotsford-Airport	2018-08-23	39.9
Abbotsford-Mill Lake	2018-08-23	46.3
Agassiz	2018-08-23	68.5
Burnaby South	2018-08-23	39.8
Burnaby-Kensington	2018-08-23	43.7
Hope	2018-08-23	82.7
Horseshoe Bay	2018-08-23	52.5
Langley	2018-08-23	33.3
Mission	2018-08-23	50.2
N. Vancouver-2nd Narrows	2018-08-23	50.2
N. Vancouver-Mahon Park	2018-08-23	49.6
New Westminster	2018-08-23	41.7
North Delta	2018-08-23	43.9
Pitt Meadows	2018-08-23	47.2
Port Moody	2018-08-23	49.6
Chilliwack	2018-08-23	59.7
Richmond South	2018-08-23	32.5
Richmond-Airport	2018-08-23	33.3
Surrey	2018-08-23	34.9
Tsawwassen	2018-08-23	34.3
Vancouver Clark Drive	2018-08-23	48.2
Chilliwack	2018-08-25	28.2
Langley	2018-08-25	30.5
Mission	2018-08-25	32.7
New Westminster	2018-08-25	28.6
Surrey	2018-08-25	29.8
Agassiz	2018-09-06	32.5
Hope	2018-09-06	37.1

Lower Fraser Valley Air Zone Report (2017-2019)



a. NASA Worldview, Aug. 3, 2017



b. NASA Worldview, Aug. 7, 2017



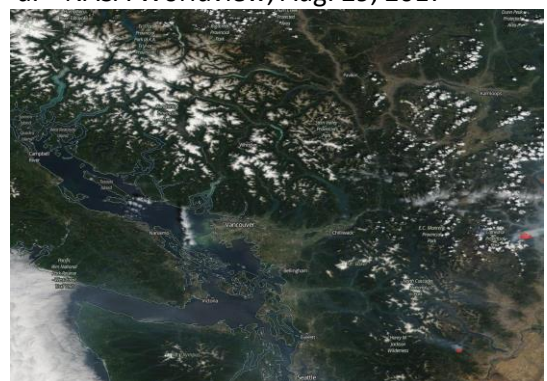
c. NASA Worldview, Aug. 10, 2017



d. NASA Worldview, Aug. 29, 2017



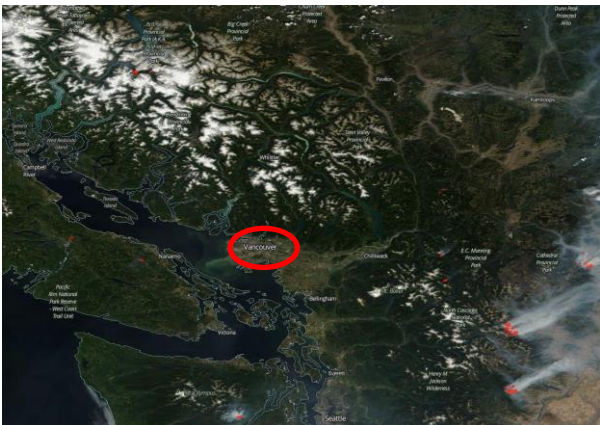
e. NASA Worldview, Jul. 26, 2018



f. NASA Worldview, Jul. 30, 2018

Figure II-1. Satellite images covering Aug. 3, 7, 10 and 29, 2017 and Jul. 26 and 30, 2018, showing wildfire smoke (grey plumes) over the southwest coast, including the LfV Air Zone. Red dots indicate fires and thermal anomalies. Large red circle in Figure II-1(a) identifies Vancouver on map. Source of images: NASA Worldview Snapshots at: <https://worldview.earthdata.nasa.gov/>.

Lower Fraser Valley Air Zone Report (2017-2019)



a. NASA Worldview, Aug. 8, 2018



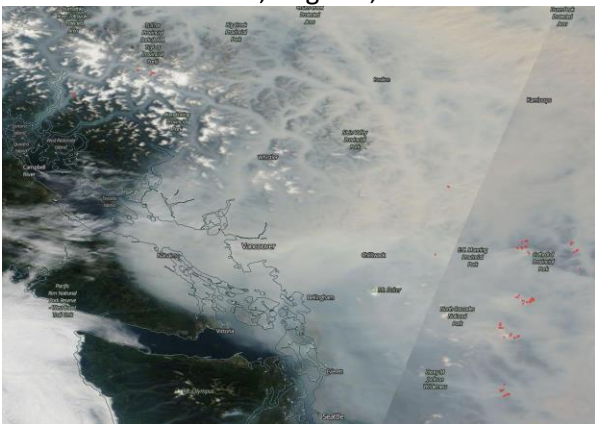
b. NASA Worldview, Aug. 9, 2018



c. NASA Worldview, Aug. 13, 2018.



d. NASA Worldview, Aug. 16, 2018.



e. NASA Worldview, Aug. 18, 2018.



f. NASA Worldview, Aug. 22, 2018.

Figure II-2. Satellite images covering Aug. 8-9, 13, 16, 18 and 22, 2018, showing wildfire smoke (grey plumes) over the southwest coast, including the LFV Air Zone. Red dots indicate fires and thermal anomalies. Large red circle in Figure II-2(a) identifies Vancouver on map. Source of images: NASA Worldview Snapshots at: <https://worldview.earthdata.nasa.gov/>.

Appendix III – Supporting analysis of wildfire influences on ozone levels in the Lower Fraser Valley Air Zone (2017-2019)

This appendix provides additional supporting information on the identification of ozone events that were influenced by wildfire smoke. In this context, an ozone event is considered to be a day in which 8-hour daily maximum ozone concentrations exceeded the CAAQS level of 63 ppb.

Potential wildfire-influenced days were initially flagged on the basis of elevated ozone and PM_{2.5} concentrations, the issuance of a wildfire-related air quality advisory and/or satellite images showing smoke in the region. This information was summarized in Table II-2.

While PM_{2.5} concentrations are typically low during the summer months if not for the presence of wildfire smoke, ozone concentrations in the Lower Fraser Valley typically peak in the summer, during stagnant periods characterized by sunny conditions, high temperatures and light winds. To assess the likelihood that high ozone days were driven by the presence of wildfire smoke and not just the typical conditions conducive to ozone buildup, ozone and PM_{2.5} concentrations for the day in question were compared against historical data for the months of June, July, August and September using an approach developed by Howe for the 2015-2017 Lower Fraser Valley Air Zone Report (see: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/air/reports-pub/air-zone-reports/2015-2017/lfv_air_zone_report_2015-2017.pdf).

A series of percentile curves were constructed for ozone and PM_{2.5} and compared to hourly concentrations for each day in question. A “percentile” refers to the value below which a given percentage of values are found. For example, the 50th percentile curve is created by finding the 50th percentile for each hour of the day during the summer months between 2009-2019.⁸ Temperature data from the day in question are also presented, as temperature is a useful indicator of solar radiation (a key input for ozone production), with temperatures in excess of 31°C typically associated with ozone concentrations in excess of 75 ppb in the eastern LFV (Doerksen, pers. comm.).

Information from these plots can be used to determine if ozone and PM_{2.5} levels on the day in question were historically high (e.g. equal to or greater than 99% of measurements in previous years) compared to the past several years and/or showed a different diurnal profile than otherwise expected (such as peak ozone concentrations occurring earlier or later in the day than normally found).

For percentile plots compared to 2017 ozone events, the reader is referred to the 2015-2017 Lower Fraser Valley Air Zone Report. Percentile plots compared to 2018 ozone events are provided in Figures III-1 to III-7 for Hope and Figures III-8 to III-13 for Mission. In all examples, historical levels of ozone and PM_{2.5} were reached for at least part of the day. In some cases, sharp peaks were observed in PM_{2.5} levels that were not otherwise attributable to local activities, such as on July 27, 2018 in Mission (Figure III-8)

⁸ Note: Howe (2019) constructed percentile curves using ozone data collected from 2009-2018. In the current report, data from the summers of 2017 are excluded as they were both considered extreme wildfire seasons.

and Aug. 22, 2018 in Hope (Figure III-7). On July 28, 2018, $PM_{2.5}$ levels at Hope monotonically increased throughout the day to reach 99th percentile levels in the late evening (Figure III-3), although these levels were not excessively high (i.e. did not exceed the CAAQS level of $28 \mu\text{g}/\text{m}^3$). Satellite images during this period (e.g. Figures II-1(e) and (f)) showed a layer of light haze over the region. An ozone-related advisory in place during this time also referenced the presence of a layer of wildfire smoke over the south coast that had likely resulted from distant wildfires in Eurasia and Alaska, and a bog fire in Richmond. Although not as obvious as other examples, the ozone event from Jul. 27-30, 2018 and including Jul. 28, 2018 met the criteria for “wildfire-influenced” used in these analyses.

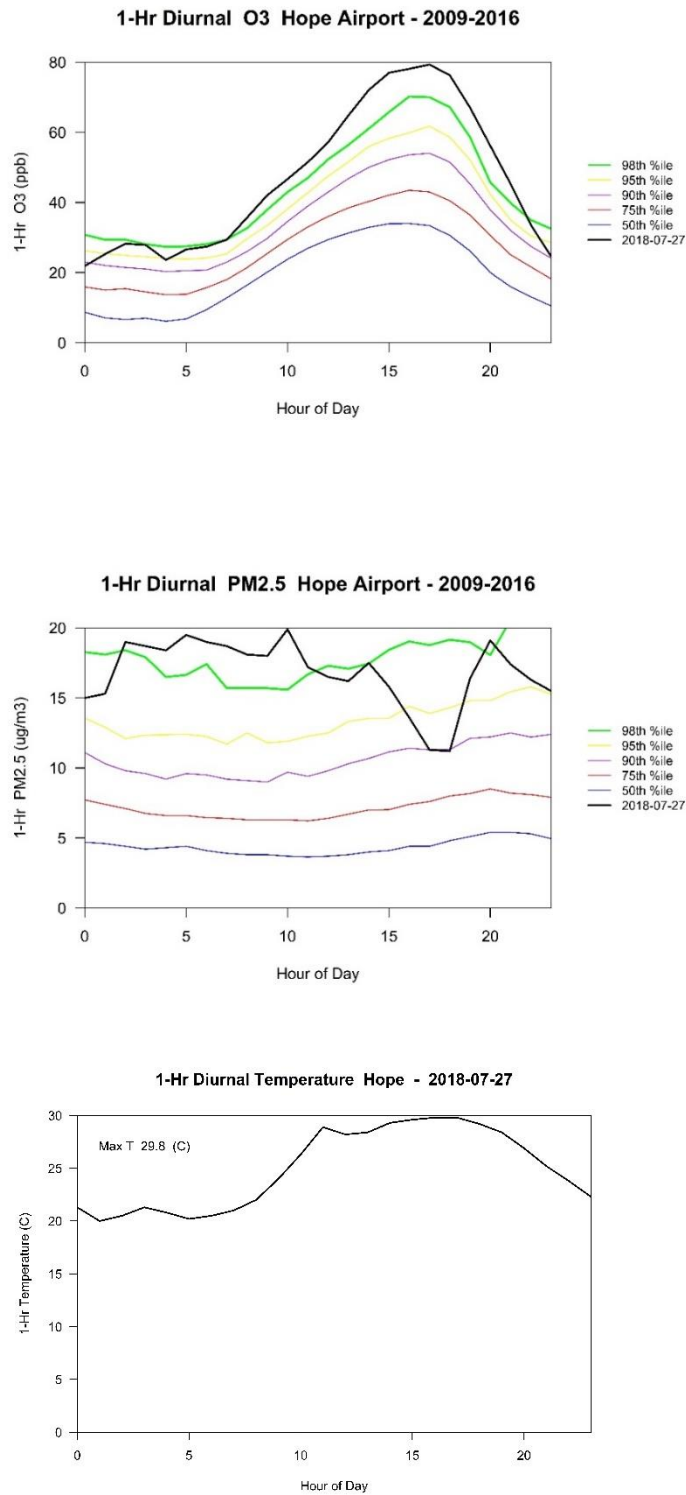


Figure III-1. Historical plots of ozone (upper) and PM_{2.5} (middle) concentrations and plot of temperature (lower) at Hope Airport, July 27, 2018.

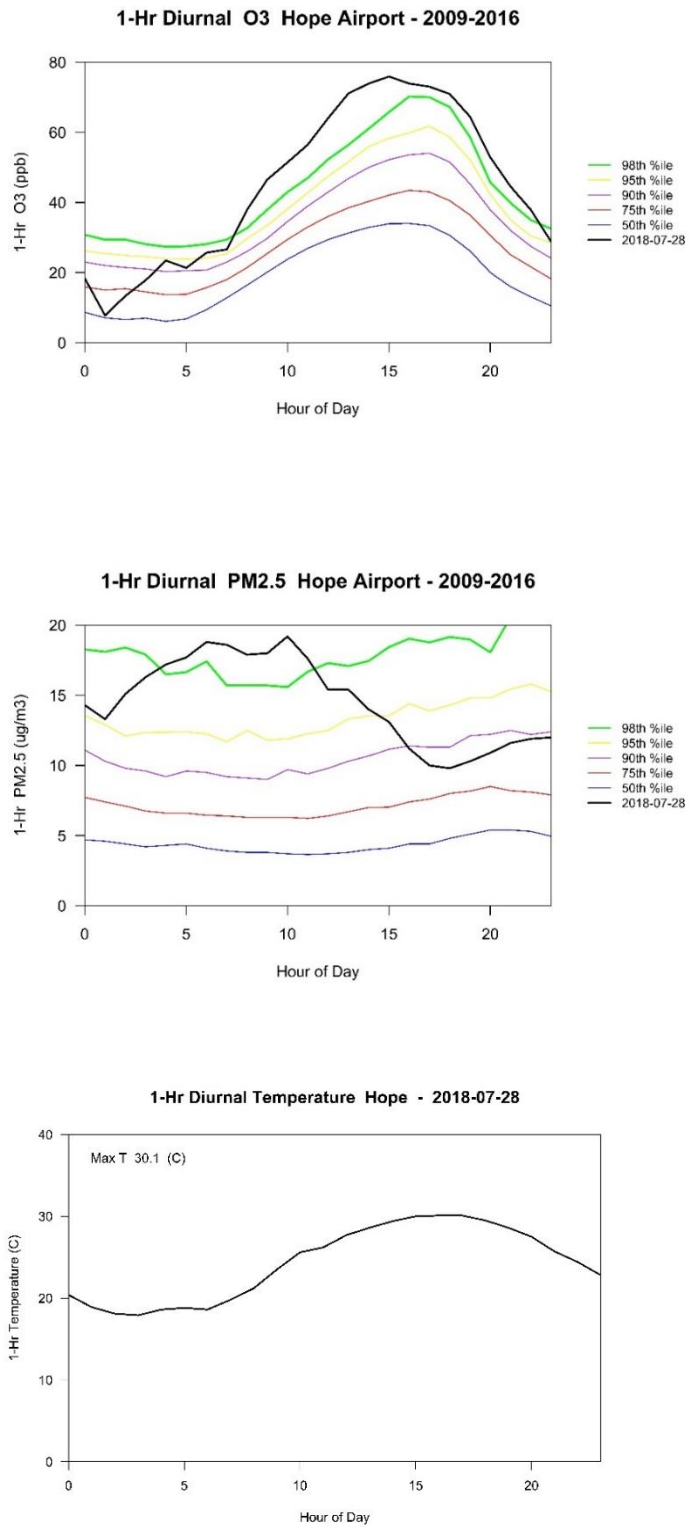


Figure III-2. Historical plots of ozone (upper) and PM_{2.5} (middle) concentrations and plot of temperature (lower) at Hope Airport, July 28, 2018.

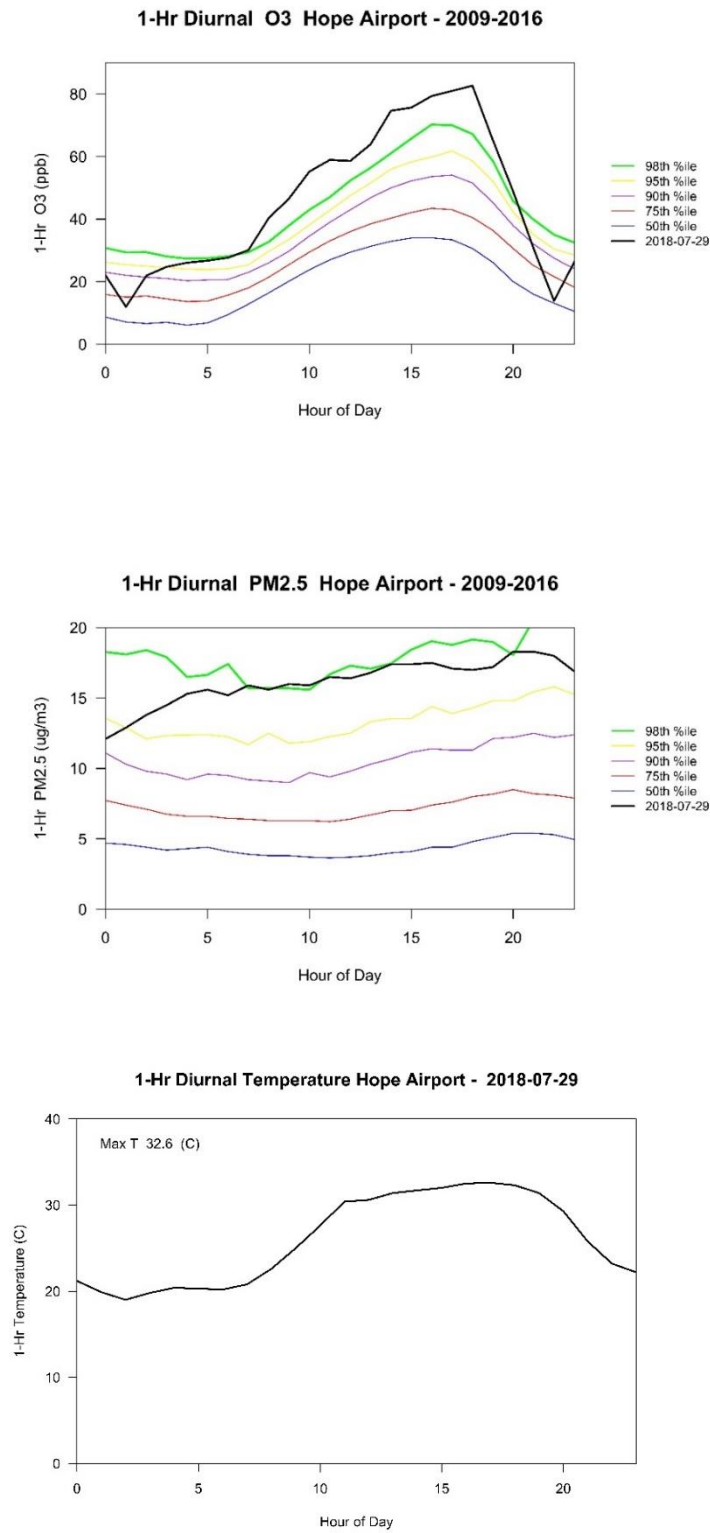


Figure III-3. Historical plots of ozone (upper) and PM_{2.5} (middle) concentrations and plot of temperature (lower) at Hope Airport, July 29, 2018.

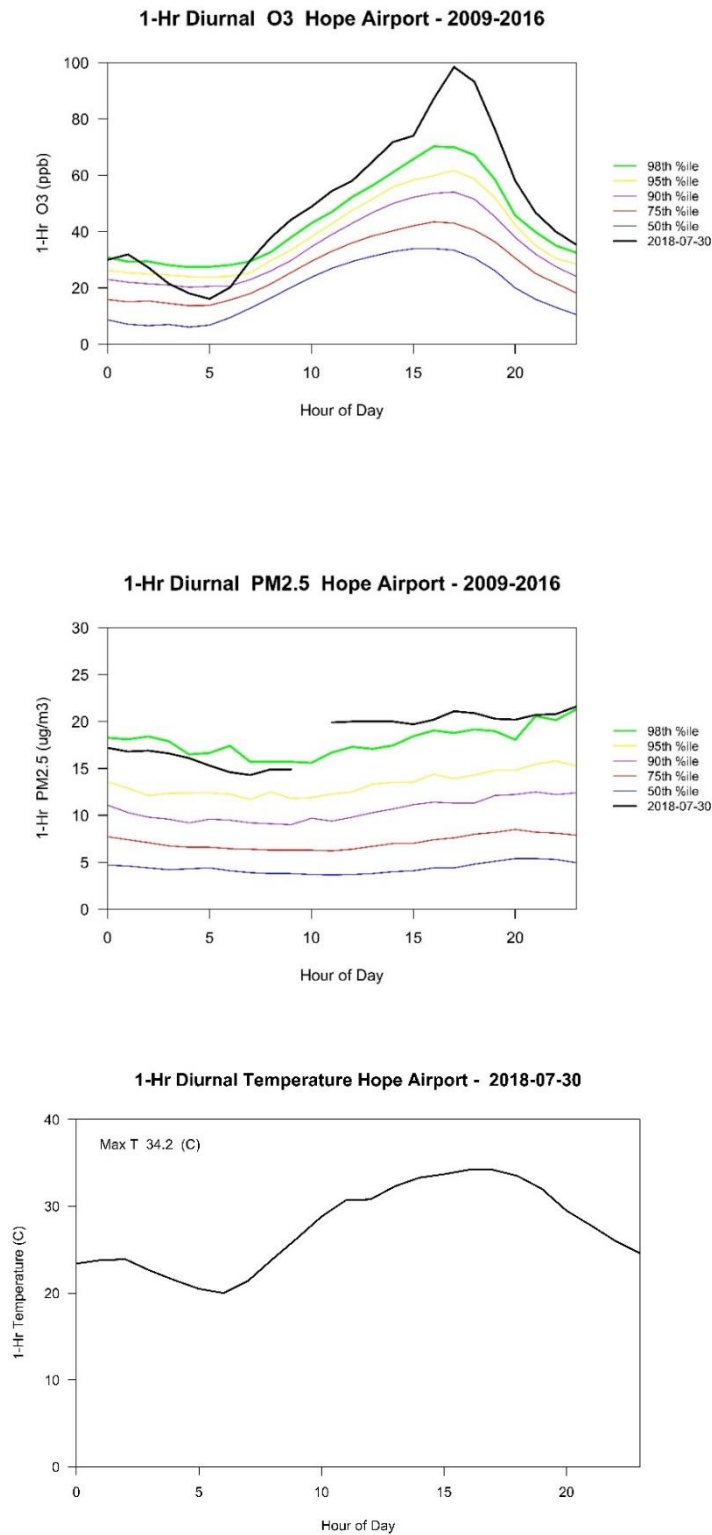


Figure III-4. Historical plots of ozone (upper) and PM_{2.5} (middle) concentrations and plot of temperature (lower) at Hope Airport, July 30, 2018.

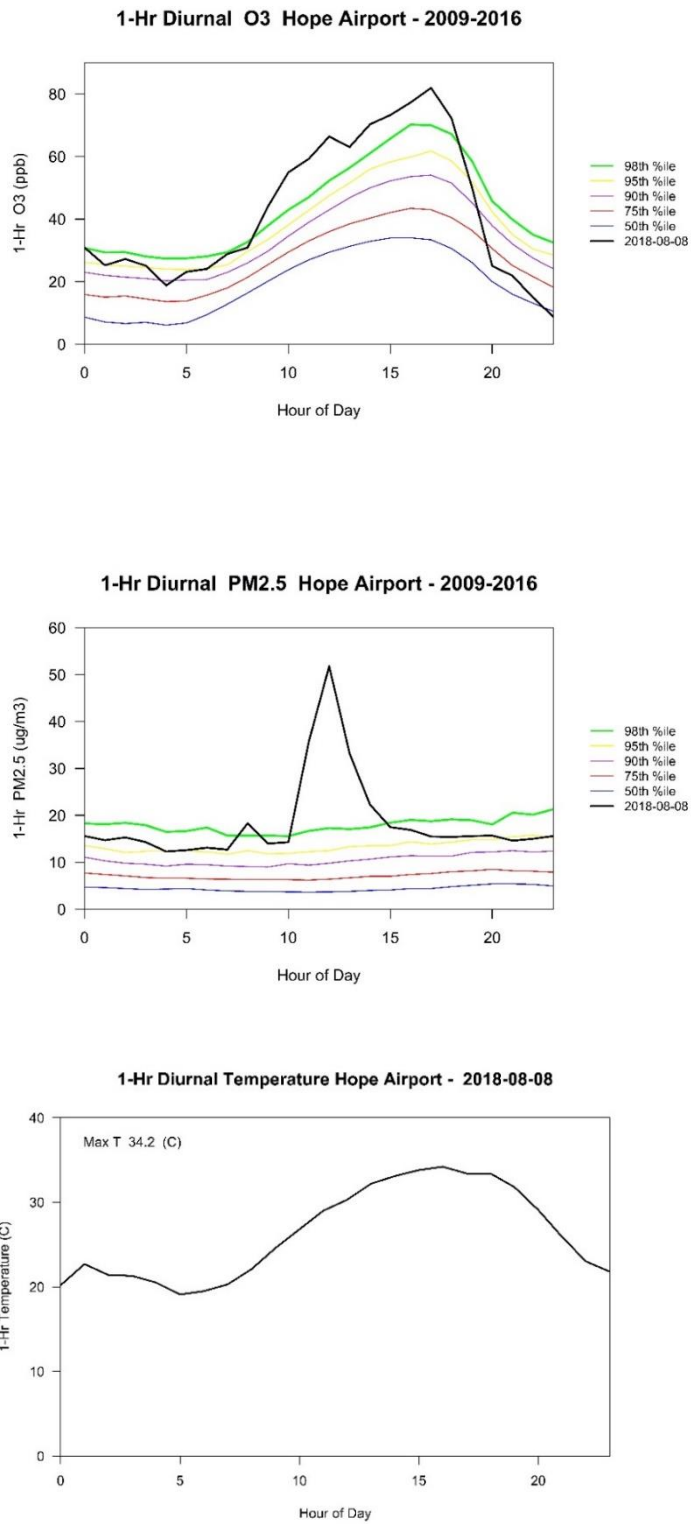


Figure III-5. Historical plots of ozone (upper) and PM_{2.5} (middle) concentrations and plot of temperature (lower) at Hope Airport, August 8, 2018.

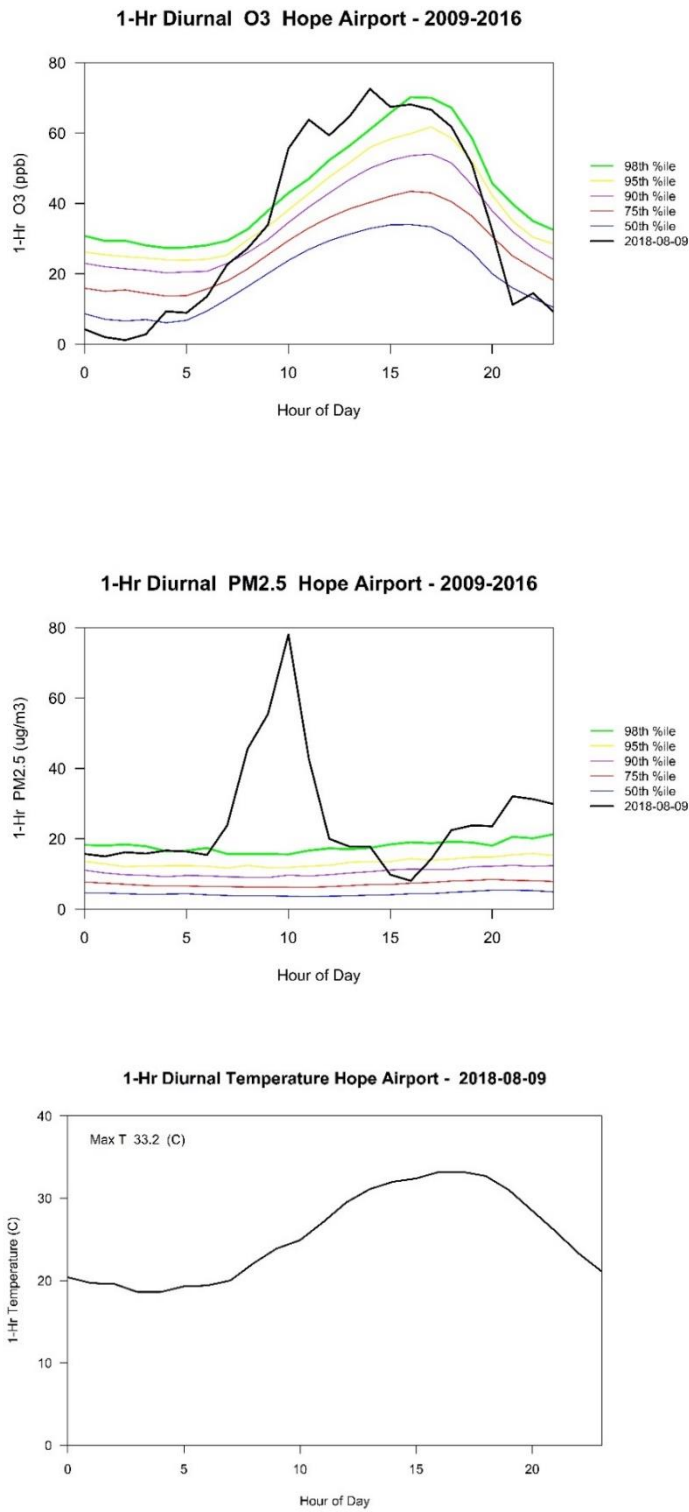


Figure III-6. Historical plots of ozone (upper) and PM_{2.5} (middle) concentrations and plot of temperature (lower) at Hope Airport, August 9, 2018.

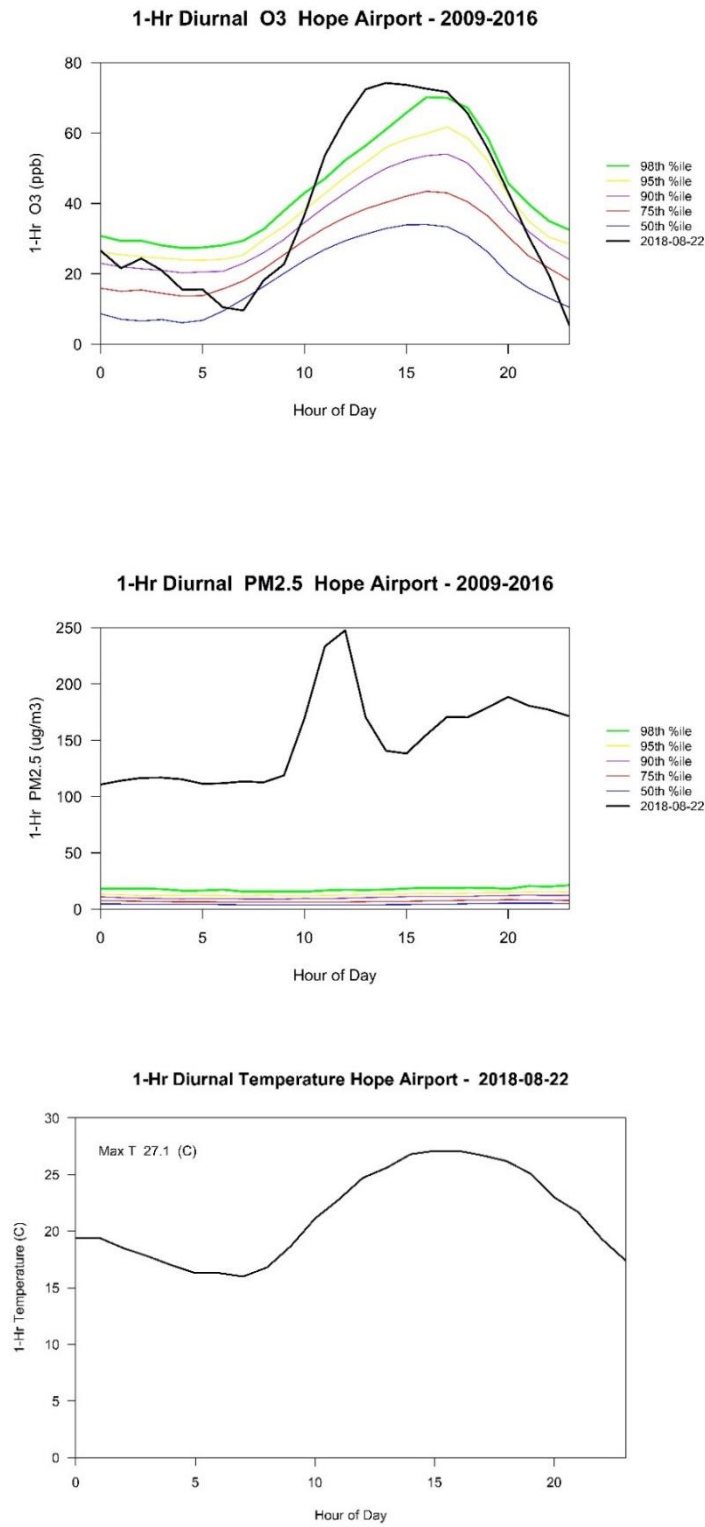


Figure III-7. Historical plots of ozone (upper) and PM_{2.5} (middle) concentrations and plot of temperature (lower) at Hope Airport, August 22, 2018.

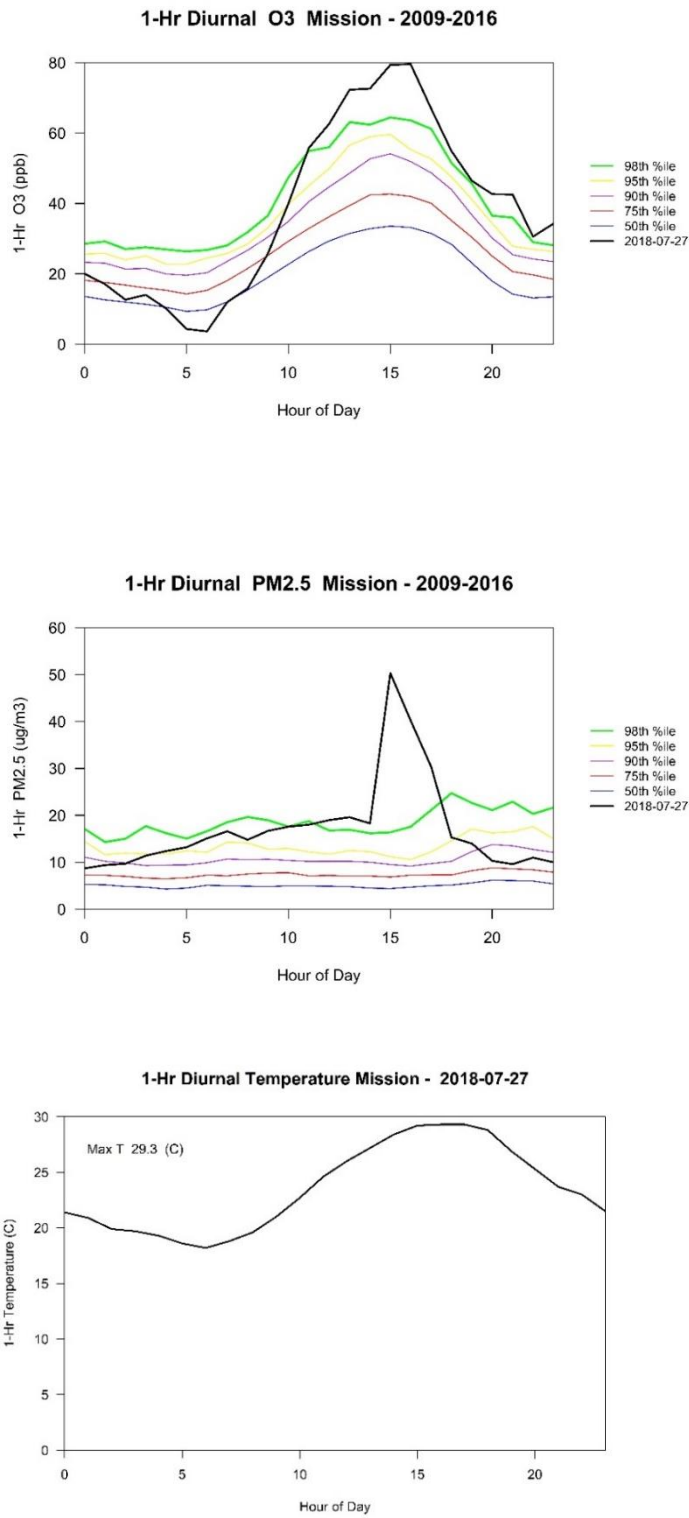


Figure III-8. Historical plots of ozone (upper) and PM_{2.5} (middle) concentrations and plot of temperature (lower) at Mission Works Yard, July 27, 2018.

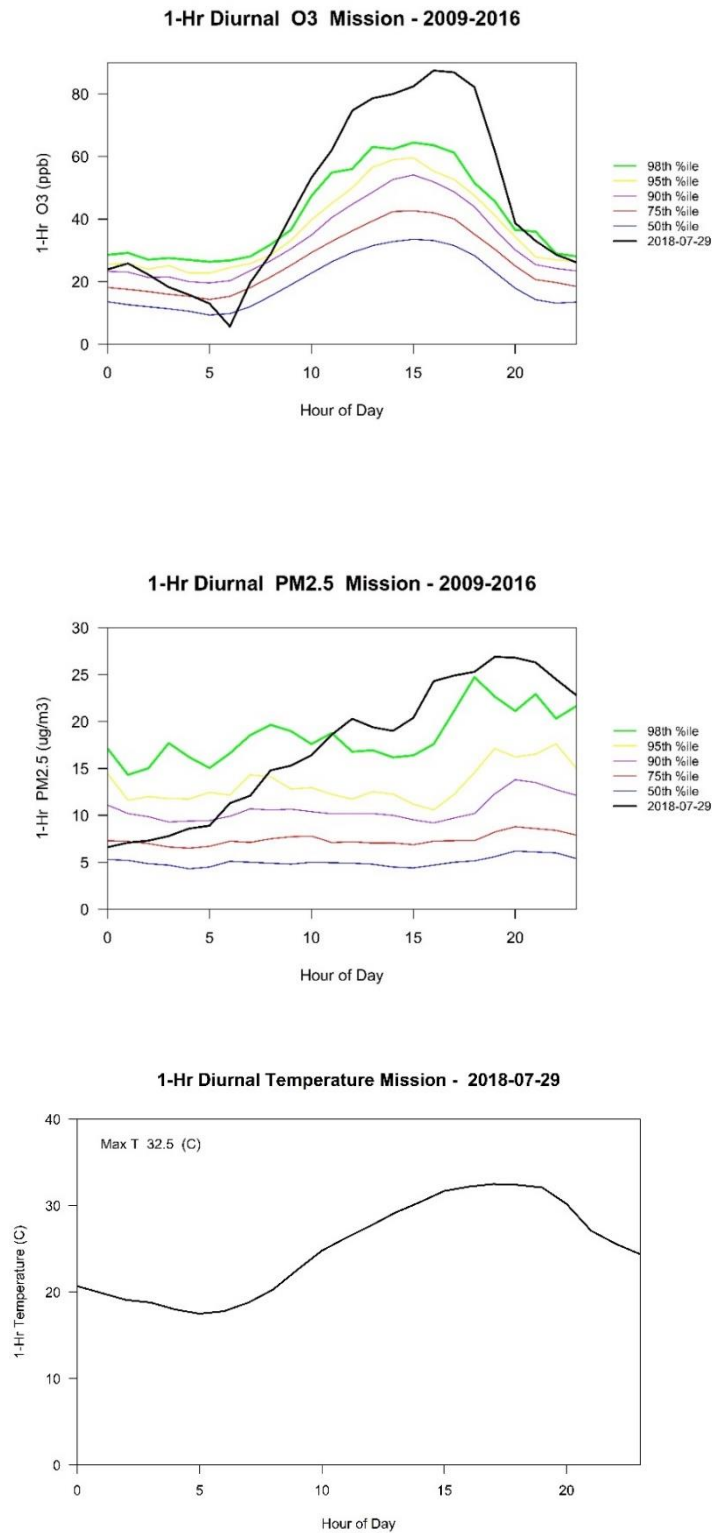


Figure III-9. Historical plots of ozone (upper) and PM_{2.5} (middle) concentrations and plot of temperature (lower) at Mission Works Yard, July 29, 2018.

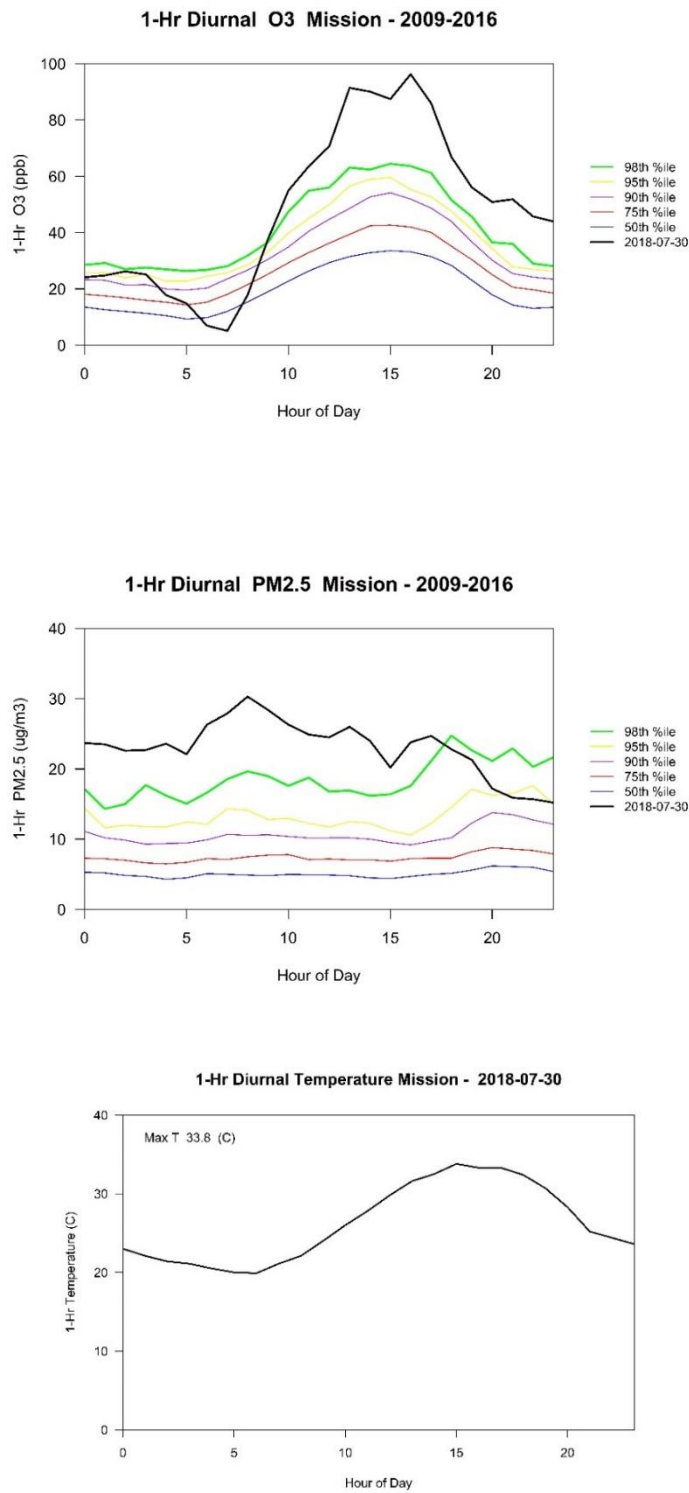


Figure III-10. Historical plots of ozone (upper) and PM_{2.5} (middle) concentrations and plot of temperature (lower) at Mission Works Yard, July 30, 2018.

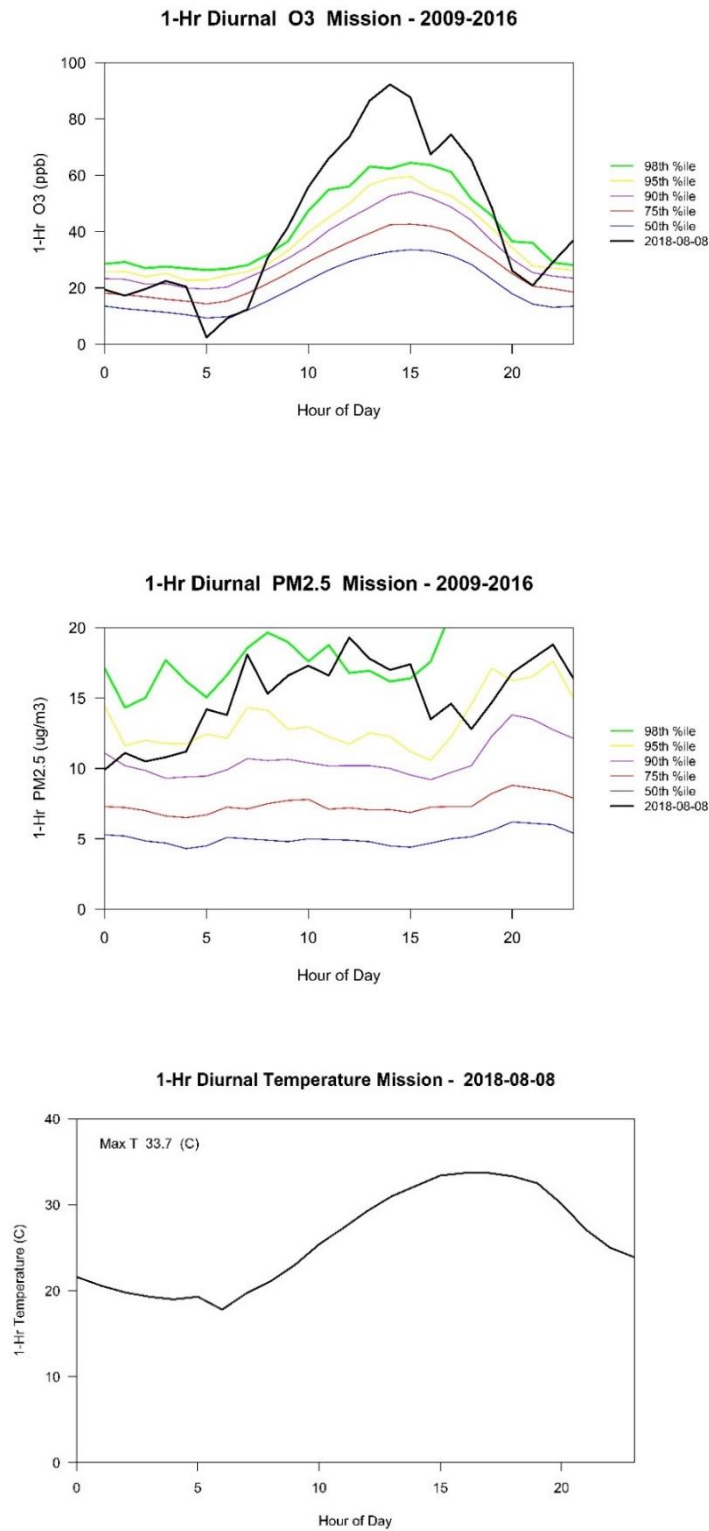


Figure III-11. Historical plots of ozone (upper) and PM_{2.5} (middle) concentrations and plot of temperature (lower) at Mission Works Yard, August 8, 2018.

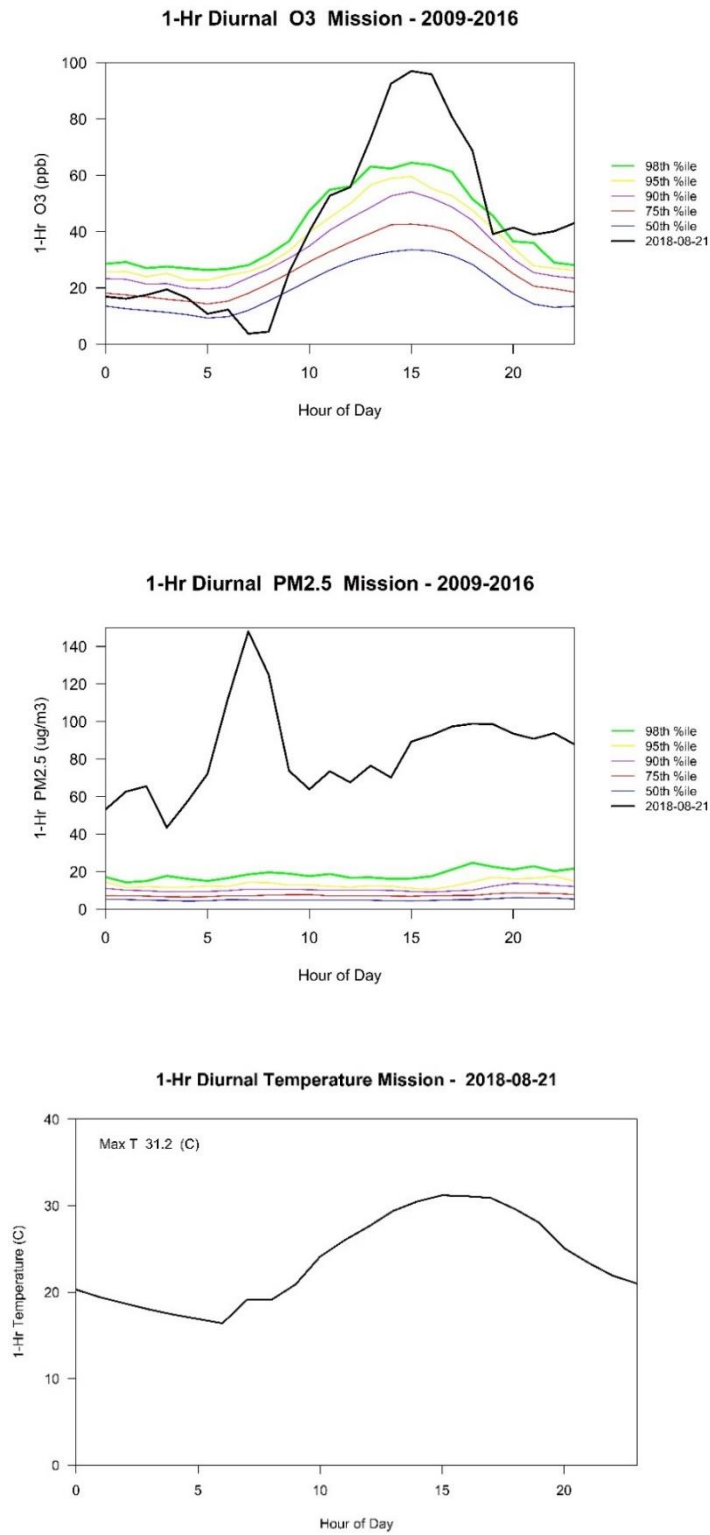


Figure III-12. Historical plots of ozone (upper) and PM_{2.5} (middle) concentrations and plot of temperature (lower) at Mission Works Yard, August 21, 2018.

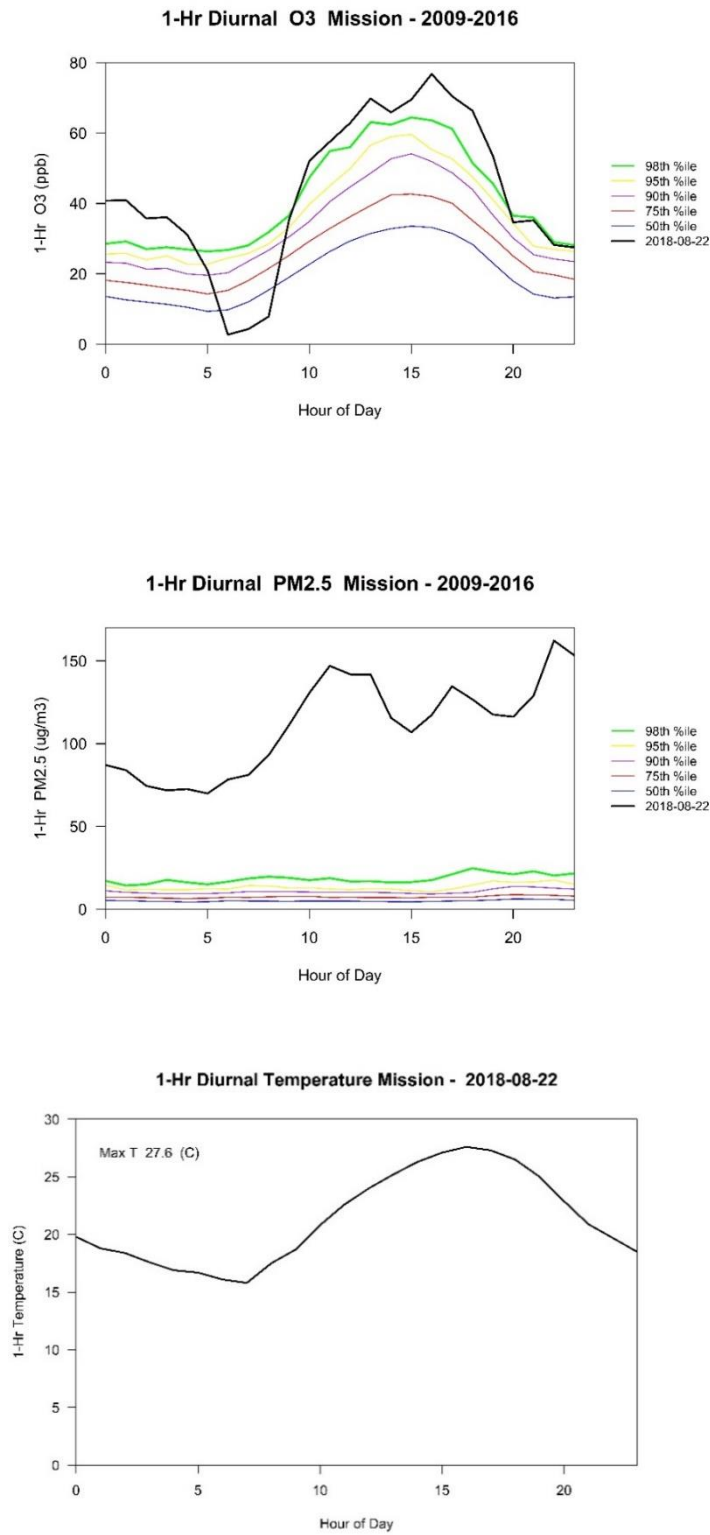


Figure III-13. Historical plots of ozone (upper) and PM_{2.5} (middle) concentrations and plot of temperature (lower) at Mission Works Yard, August 22, 2018.