Introduction

This is the fifth 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 particulates ($PM_{2.5}$), 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 (see Figure 1) is one of seven broad air zones across the province. 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 Table 1.

Figure 1. Lower Fraser Valley Air Zone.

Table 1. Air zone management framework for ground-level ozone and $PM_{2.5}$. The CAAQS define the upper threshold, separating the "red" and "orange" management levels.

Management Level	O_3 (ppb)		$PM_{2.5}$ – Annual (µg/m³)		$PM_{2.5}$ - 24h (µg/m³)	
	2015	**2020**	**2015**	**2020**	**2015**	**2020**
Red	Actions for Achieving Air Zone CAAQS					
Threshold (CAAQS)	63	62	10	8.8	28	27
Orange	Actions for Preventing CAAQS Exceedance					
Threshold	56		6.4		19	
Yellow	Actions for Preventing Air Quality Deterioration					
Threshold	50		4		10	
Green	Actions for Keeping Clean Areas Clean					

Ozone Levels

Ozone measurements in the LFV Air Zone are summarized in Figure 2. Concentrations ranged from 34 ppb in downtown Vancouver to 64 ppb in Hope.[1] All sites achieved the national standard of 63 ppb, with the exception of Hope.

Trends in ozone levels are shown in Figure 3.[2] Over the 10-year period from 2008-2017, Hope, Port Moody and Burnaby South recorded their highest ozone levels in 2017.

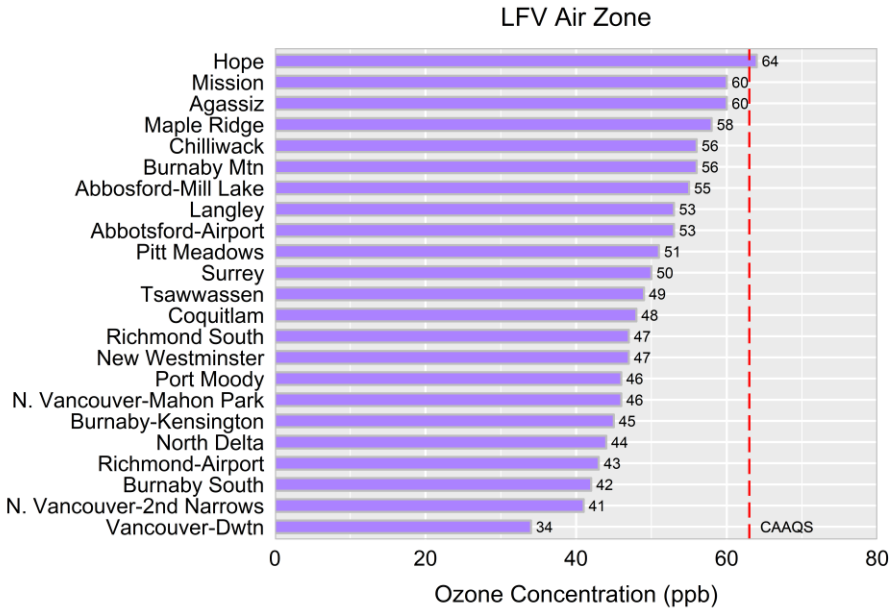


Figure 2. Ozone concentrations in the LFV Air Zone, based on annual 4th highest daily 8-hour maxima, averaged over 2015-2017. Red dashed line identifies the CAAQS of 63 ppb.

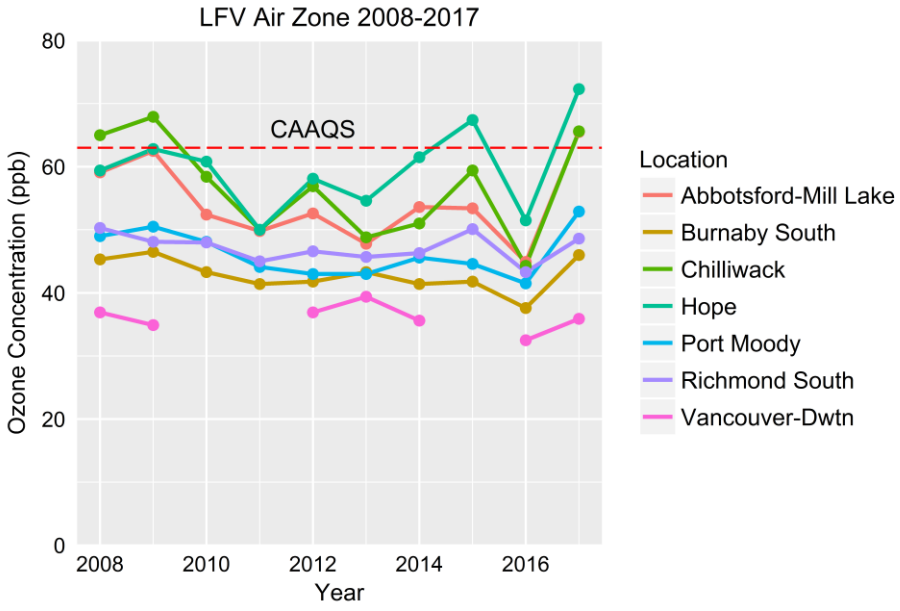


Figure 3. Trends in ozone concentrations (2008-2017), based on annual 4th highest daily 8-hour maxima for a single year. Red dashed line identifies CAAQS of 63 ppb.

[1] Concentrations based on 4th highest daily 8-hour maximum, averaged over three years (2015-2017).
[2] Concentrations based on 4th highest daily 8-hour maximum, averaged over a single year.

$PM_{2.5}$ Levels

$PM_{2.5}$ refers to inhalable particles up to 2.5 micrometres in diameter. $PM_{2.5}$ measurements are summarized in Figure 4. All measurements for this reporting period were based on the Federal Equivalent Method (FEM), which provides a more complete measure of $PM_{2.5}$ than the older TEOM instruments.

Daily concentrations (upper plot) ranged from 15 to 32 µg/m³.[3] All sites achieved the national standard of 28 µg/m³ with the exception of Hope. Annual concentrations (lower plot) ranged from 4.5 to 6.8 µg/m³.[4] All monitoring sites achieved the national standard of 10 µg/m³.

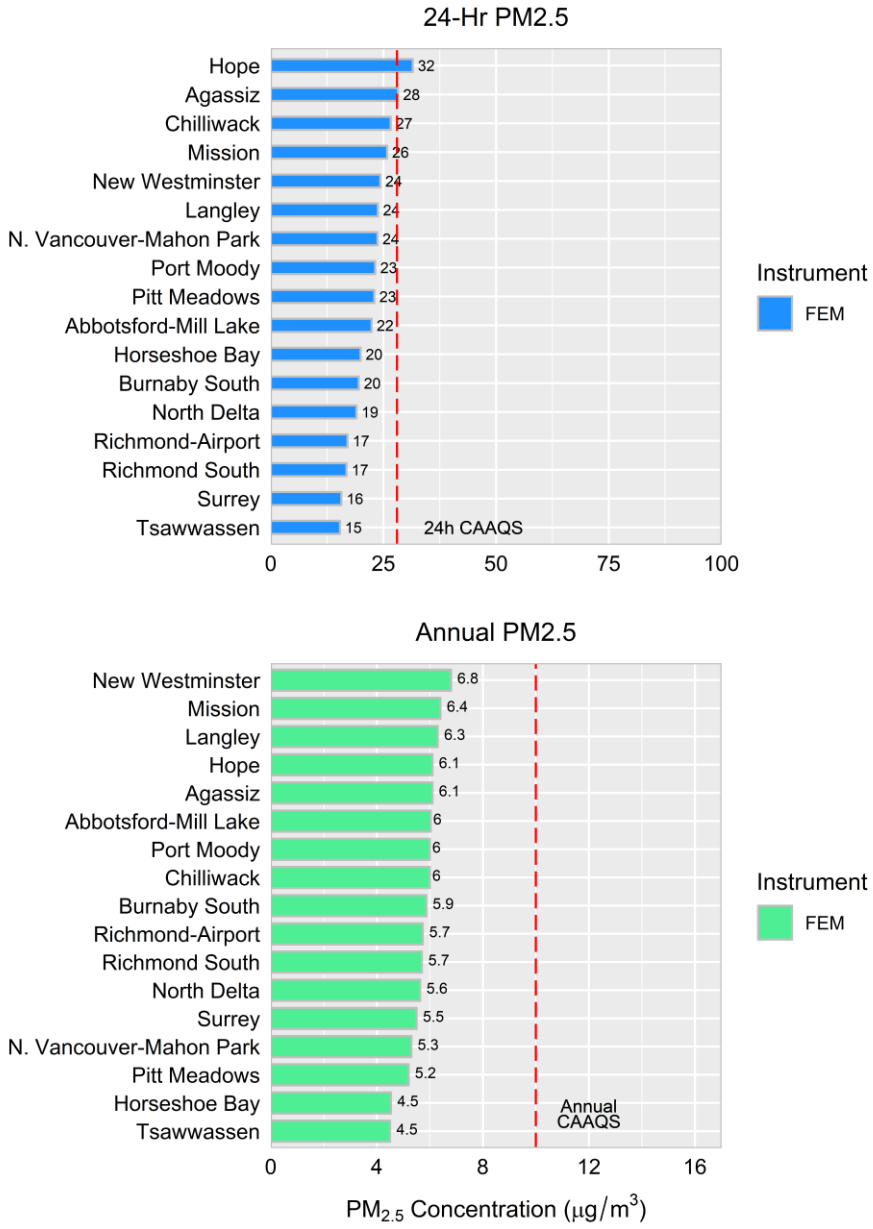


Figure 4. $PM_{2.5}$ concentrations in the LFV Air Zone. Upper plot based on 24-hour concentration (annual 98th percentile, averaged over 2015-2017). Lower plot based on annual mean concentration (averaged over 2015-2017). The red dashed lines identify CAAQS of 28 µg/m³ (upper plot) and 10 µg/m³ (lower plot).

Trends in annual mean concentrations between 2008 and 2017 are shown in Figure 5 for a subset of these sites.[5] A shift to higher reported concentrations is seen with the change from TEOM to FEM instruments from 2013 onward but concentrations have remained below the CAAQS level. Over the ten-year period from 2008-2017, five of

[3] Concentrations based on the annual 98th percentile of 24-hour values, averaged over three years (2015-2017).
[4] Concentrations based on the annual average of 24-hour values, averaged over three years (2015-2017).
[5] Concentrations based on the annual average of 24-hour values over single year.

the nine sites shown in Figure 5 recorded their highest average concentrations in 2017, and all nine sites recorded their highest daily concentrations in 2017 (not shown). Smoke from wildfires within and outside of the air zone had a major influence on $PM_{2.5}$ levels in 2017 (see Appendix II for more information).

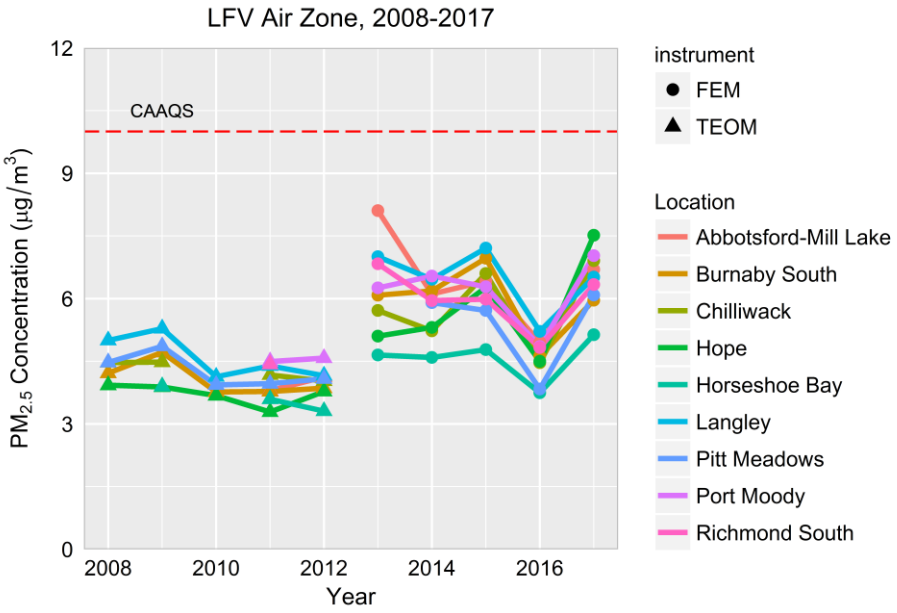


Figure 5. Annual trends in $PM_{2.5}$ concentrations (2008-2017), based on annual mean concentrations from a single year. The CAAQS value of 10 µg/m^3 is shown by the dashed line. $PM_{2.5}$ measurements prior to 2011 are reported at 25°C and 1 atm. From 2011 onward, measurements are reported at local conditions. The shift from TEOM to FEM instruments in 2013 resulted in higher monitored concentrations due to a more complete measure of $PM_{2.5}$.

Air Zone Management Levels

Air zone management levels are assigned on the basis of the highest concentrations within an air zone, excluding contributions from transboundary flows (TF) and exceptional events (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 on the basis of 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 summer of 2015 and 2017 were characterized by hot, dry conditions and an above-average number of hectares burned. These fires created smoky conditions and periods of degraded air quality in several communities across the air zone, particularly in 2017.

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 Agassiz, Hope and Maple Ridge. This highlights a need for actions to prevent future exceedances of the ozone CAAQS in the air zone.

Table 2. Summary of ozone concentrations as measured and air zone management levels for the LFV Air Zone (based on 2015-2017 data).

Location	No. Valid Years	4th Highest Daily 8-hour Maxima		Air Zone Management Level
		As Measured	TF/EE Influences Removed	
Abbotsford-Airport	3	53	53	**Goal: Preventing CAAQS Exceedance**
Abbotsford-Mill Lake	3	55	55	
Agassiz	3	60	60	
Burnaby-Mtn	3	56	56	
Burnaby-South	3	42	42	
Burnaby-Kensington	3	45	45	
Chilliwack	3	56	56	
Coquitlam	2	48	48	
Hope	3	64	59	
Langley	3	53	53	
Maple Ridge	3	58	58	
Mission	2	60	60	
N. Vancouver-2nd Narrows	3	41	41	
N. Vancouver-Mahon Park	3	46	46	
New Westminster	2	47	47	
North Delta	3	44	44	
Pitt Meadows	3	51	51	
Port Moody	3	46	46	
Richmond South	3	47	47	
Richmond-Airport	3	43	43	
Surrey	3	50	50	
Tsawwassen	3	49	49	
Vancouver-Dwtn	2	34	34	

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 a "yellow" management level, based on the prevailing $PM_{2.5}$ management level across the air zone. This indicates that $PM_{2.5}$-related actions should focus on actions to prevent air quality deterioration.

Table 3. Summary of $PM_{2.5}$ concentrations as measured and air zone management levels for the LFV Air Zone (based on 2015-2017 data).

Location	Monitor Type	No. Valid Years	Daily Mean (98th Percentile)		Annual Mean		Air Zone Management Level
			As Measured	TF/EE Removed	As Measured	TF/EE Removed	
Abbotsford-Airport	FEM	3	23	16	6.0	5.5	**Goal: Preventing Air Quality Deterioration**
Abbotsford-Mill Lake	FEM	3	22	15	6.0	5.7	
Agassiz	FEM	3	28	14	6.1	5.4	
Burnaby-South	FEM	3	20	14	5.9	5.4	
Burnaby-Kensington	FEM	3	24	12	5.8	5.1	
Chilliwack	FEM	3	27	14	6.0	5.3	
Hope	FEM	3	32	14	6.1	5.1	
Horseshoe Bay	FEM	3	20	10	4.5	3.9	
Langley	FEM	3	24	19	6.3	6.0	
Mission	FEM	3/2[6]	26	14	5.8	5.7	
New Westminster	FEM	2	24	15	6.8	6.3	
N. Vancouver-2nd Narrows	FEM	3	25	12	6.4	5.8	
N. Vancouver-Mahon Park	FEM	3	24	12	5.3	4.6	
North Delta	FEM	3	19	14	5.6	5.3	
Pitt Meadows	FEM	3	23	15	5.2	4.7	
Port Moody	FEM	3	23	12	6.0	5.4	
Richmond South	FEM	3	17	16	5.7	5.6	
Richmond-Airport	FEM	3	17	16	5.7	5.6	
Surrey	FEM	3	16	15	5.5	5.3	
Tsawwassen	FEM	3	15	13	4.5	4.4	

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.[7] This plan contains 12 strategies, 81 actions and 10 performance measures. It seeks to

[6] 24-hour value based on two complete years of data in 2015 and 2016, and one incomplete year in 2017; annual value based on two complete years of data in 2015 and 2016 only.

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 contributions to climate change. The first progress report on plan implementation was released in 2014.[8] More information on air quality-related activities in Metro Vancouver can be found at: http://www.metrovancouver.org/services/air-quality/Pages/default.aspx.

The Fraser Valley Regional District (FVRD) is in the process of updating its Air Quality Management Plan that was first developed in 1998.[9] This plan highlights several air quality issues, including ground-level ozone and $PM_{2.5}$. The FVRD is currently reviewing options for developing alternatives to open burning.

Regional air quality agencies including Metro Vancouver and the Fraser Valley Regional District developed a Regional Ground-Level Ozone Strategy in 2014.[10] 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).

[7] http://www.metrovancouver.org/services/air-quality/AirQualityPublications/IntegratedAirQualityGreenhouseGasManagementPlan-October2011.pdf
[8] http://www.metrovancouver.org/services/air-quality/AirQualityPublications/2014IAQGGMPProgressReport.pdf
[9] http://www.fvrd.ca/assets/Services/Documents/FVRD%20AQManagementPlan.pdf
[10] 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.

A myriad of different 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 exceeded the CAAQS level of 28 $\mu g/m^3$ or 8-hour daily maximum ozone concentrations exceeded the CAAQS level of 63 ppb between May and September,
- Wildfires of interest were identified based on data from B.C. Wildfire Management Branch,
- Wildfire-related air quality advisories had been issued by Metro Vancouver during the period of interest,
- NASA satellite images indicated smoke impacts over the region,
- Multiple monitoring sites in the area of concern exhibited similar air quality characteristics, suggesting a common source or contributing source, and
- Modelling studies identify enhanced pollutant concentrations due to wildfire smoke.

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 (2015-2017)

Ozone and $PM_{2.5}$ data from 2015-2017 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:

- Several wildfires of note – either due to size or proximity to populated areas – occurred in 2015 and 2017. Those closest in proximity to the LFV air zone are summarized in Table II-1. These included the Elaho, Boulder Creek and Cougar Creek fires in the vicinity of Pemberton in 2015, and the East Harrison Lake fire in 2017.
- 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 $PM_{2.5}$).
- Satellite images during these periods showed smoky plumes over much of southern B.C., including the Lower Fraser Valley Air Zone (see Figures II-1 and 2).
- Smoke transported by outflow winds from large wildfires in the interior of B.C. area (e.g. see Figure II-1d and II-2d) further added to the smoky skies experienced in the Lower Fraser Valley Air Zone during periods of 2015 and 2017.
- A past study by Teakles et al. (2017) indicated that a wildfire smoke event in 2012 was responsible for an enhancement of 8-hour ozone concentrations at coastal B.C. sites by as much as 10 ppb[11];
- Analyses by Metro Vancouver (K. Howe, pers. comm.) indicated that for a given level of solar radiation in the eastern Lower Fraser Valley, higher ozone concentrations may be expected on wildfire-impacted days (see Appendix III for further details).

Table II-1. Summary of notable wildfires in the southern interior between 2015-2017.[12]

Date Discovered	Size (ha)	Geographic Location	Description
2015-06-14	12,495	Elaho 67 km	67 km east of Pemberton
2015-06-30	6735	Boulder Creek	23 km northwest of Pemberton Meadows; resulted in evacuation orders
2015-07-01	2985	Cougar Creek	South of the Nahatlach River; resulted in evacuation alerts
2015-07-02	423	Old Sechelt mine	2 km northwest of Sechelt; resulted in evacuation orders and alerts
2017-07-01	202	Harrison Lake East	30 km north of Harrison Hot Springs near the mouth of Big Silver Creek; Prompted evacuation alerts

[11] Teakles, A.D., So, R., Ainslie, B. et al. (2017) Impacts of the July 2012 Siberian fire plume on air quality in the Pacific Northwest. Atmos. Chem. Phys. 17, pp. 2593-2611.

[12] https://www2.gov.bc.ca/gov/content/safety/wildfire-status/about-bcws/wildfire-history/wildfire-season-summary

Table II-2. Days on which the 8-hour ozone concentrations exceeded the CAAQS level of 63 ppb (2015-2017) at Hope, BC. Wildfire-influenced concentrations are highlighted in red. Rolling 8-hour average values are based on 1-hour concentrations rounded to the nearest integer.

Date	End Hour	8-Hr Daily Max O_3 (ppb)	24-hr $PM_{2.5}$ ($\mu g/m^3$)	Max T (°C)	AQ Advisory in Effect
2015-06-27	19:00	76.2	10.0	33.1	Yes (due to ground-level ozone)
2015-07-02	19:00	67.2	7.4	32.9	None
2015-07-04	19:00	64.2	8.3	31.1	None
2015-07-06	19:00	64.4	28.4	29.6	Yes (due to PM from wildfires outside region)
2015-07-08	19:00	75.7	31.0	30.9	Yes (due to PM from wildfires outside region)
2015-07-09	19:00	77.4	35.8	31.2	Yes (due to PM from wildfires outside region)
2017-07-05	20:00	67.5	8.3	29.3	None
2017-07-06	19:00	66.7	9.7	29.4	Yes (due to ground-level ozone)
2017-08-03	19:00	78.3	89.3	31.5	Yes (due to PM from interior wildfires)
2017-08-07	19:00	72.0	73.9	29.3	Yes (due to PM from interior wildfires)
2017-08-10	19:00	78.7	58.5	31.4	Yes (due to PM from interior wildfires + ozone)
2017-08-11	19:00	68.6	41.6	30.3	Yes (due to PM from interior wildfires + ozone)
2017-08-29	20:00	75.9	28.5	32.1	Yes (due to PM from PNW wildfires + ozone)

Table II.3 – Wildfire-influenced $PM_{2.5}$ data from 2015.

Location	Date	Daily Mean ($\mu g/m^3$)	Wildfire Smoke-related Air Quality Advisory?
Abbotsford-Airport	2015-07-05	35	Yes
Burnaby South	2015-07-05	55.6	Yes
Burnaby-Kensington Park	2015-07-05	78.3	Yes
Chilliwack	2015-07-05	30.4	Yes
Horseshoe Bay	2015-07-05	65.9	Yes
Langley	2015-07-05	45.7	Yes
Mission	2015-07-05	29.8	Yes
North Delta	2015-07-05	57.3	Yes
N. Vancouver-2nd Narrows	2015-07-05	46.0	Yes
N. Vancouver-Mahon Park	2015-07-05	59.9	Yes
Pitt Meadows	2015-07-05	50.8	Yes
Port Moody	2015-07-05	56	Yes

Table II-3 (continued).

Location	Date	Daily Mean ($\mu g/m^3$)	Wildfire Smoke-related Air Quality Advisory?
Richmond South	2015-07-05	49.3	Yes
Richmond-Airport	2015-07-05	54.2	Yes
Surrey	2015-07-05	58.3	Yes
Tsawwassen	2015-07-05	56.8	Yes
Abbotsford-Airport	2015-07-06	44.9	Yes
Abbotsford-Mill Lake	2015-07-06	82.5	Yes
Agassiz-	2015-07-06	37.4	Yes
Burnaby South	2015-07-06	48.3	Yes
Burnaby-Kensington Park	2015-07-06	49.8	Yes
Chilliwack-Airport	2015-07-06	36.6	Yes
Hope-Airport	2015-07-06	28.4	Yes
Horseshoe Bay	2015-07-06	59.6	Yes
Langley	2015-07-06	35.9	Yes
Mission	2015-07-06	62.1	Yes
North Delta	2015-07-06	34.6	Yes
N. Vancouver-2nd Narrows	2015-07-06	35.2	Yes
N. Vancouver-Mahon Park	2015-07-06	53.3	Yes
Pitt Meadows	2015-07-06	41.5	Yes
Port Moody	2015-07-06	56.4	Yes
Surrey	2015-07-06	33.2	Yes
Burnaby-Kensington Park	2015-07-08	28.7	Yes
Hope-Airport	2015-07-08	31	Yes
Horseshoe Bay	2015-07-08	33	Yes
N. Vancouver-2nd Narrows	2015-07-08	28.9	Yes
N. Vancouver-Mahon Park	2015-07-08	34.5	Yes
Port Moody	2015-07-08	29.4	Yes
Agassiz-Municipal Hall	2015-07-09	34	Yes
Burnaby-Kensington Park	2015-07-09	28.7	Yes
Hope-Airport	2015-07-09	35.8	Yes
Horseshoe Bay	2015-07-09	32.7	Yes
N. Vancouver-Mahon Park	2015-07-09	31.7	Yes
Abbotsford-Airport	2015-08-23	30.1	Yes
Agassiz-Municipal Hall	2015-08-23	43.7	Yes
Chilliwack-Airport	2015-08-23	39.9	Yes
Hope-Airport	2015-08-23	42.5	Yes

Table II-4 – Wildfire-influenced $PM_{2.5}$ data from 2017.

Location	Date	Daily Mean ($\mu g/m^3$)	Wildfire Smoke-related Air Quality Advisory?
Agassiz-Municipal Hall	2017-08-01	38.5	Yes
Chilliwack-Airport	2017-08-01	30.3	Yes
Hope-Airport	2017-08-01	62.6	Yes
Abbotsford-Mill Lake	2017-08-02	57.8	Yes
Agassiz-Municipal Hall	2017-08-02	98.6	Yes
Burnaby-Kensington Park	2017-08-02	56.3	Yes
Burnaby-South	2017-08-02	54.4	Yes
Chilliwack-Airport	2017-08-02	88.2	Yes
Hope-Airport	2017-08-02	97.5	Yes
Horseshoe Bay	2017-08-02	53.3	Yes
Langley Central	2017-08-02	37.9	Yes
Mission-School Works Yard	2017-08-02	68.1	Yes
New Westminster-Sapperton Park	2017-08-02	44.4	Yes
North Delta	2017-08-02	37.1	Yes
N. Vancouver-Mahon Park	2017-08-02	41	Yes
N. Vancouver-2nd Narrows	2017-08-02	45.9	Yes
Pitt Meadows-Meadowlands School	2017-08-02	41.4	Yes
Abbotsford-Airport	2017-08-03	65.6	Yes
Abbotsford-Mill Lake	2017-08-03	55.5	Yes
Agassiz- Municipal Hall	2017-08-03	78.8	Yes
Burnaby-Kensington Park	2017-08-03	67.9	Yes
Burnaby South	2017-08-03	47.5	Yes
Chilliwack-Airport	2017-08-03	74.1	Yes
Hope-Airport	2017-08-03	89.3	Yes
Horseshoe Bay	2017-08-03	70.4	Yes
Langley Central	2017-08-03	49.3	Yes
Mission-School Works Yard	2017-08-03	69.9	Yes
New Westminster-Sapperton	2017-08-03	52.6	Yes
North Delta	2017-08-03	45.5	Yes
N. Vancouver Mahon Park	2017-08-03	66.1	Yes
N. Vancouver - 2nd Narrows	2017-08-03	70.2	Yes
Pitt Meadows-Meadowlands School	2017-08-03	58.7	Yes
Port Moody-Rocky Point Park	2017-08-03	74.7	Yes
Abbotsford-Airport	2017-08-04	34.2	Yes
Abbotsford-Mill Lake	2017-08-04	40.5	Yes
Agassiz-Municipal Hall	2017-08-04	72	Yes
Burnaby-Kensington Park	2017-08-04	46.1	Yes

Table II-4 (continued)

Location	Date	Daily Mean ($\mu g/m^3$)	Wildfire Smoke-related Air Quality Advisory?
Burnaby South	2017-08-04	29.1	Yes
Chilliwack-Airport	2017-08-04	62.7	Yes
Hope-Airport	2017-08-04	79.4	Yes
Horseshoe Bay	2017-08-04	37.6	Yes
Langley Central	2017-08-04	31.9	Yes
Mission-School Works Yard	2017-08-04	46.7	Yes
New Westminster - Sapperton	2017-08-04	30.2	Yes
North Delta	2017-08-04	30.4	Yes
N. Vancouver-Mahon Park	2017-08-04	48.5	Yes
N. Vancouver - 2nd Narrows	2017-08-04	43.1	Yes
Pitt Meadows-Meadowlands School	2017-08-04	39.3	Yes
Port Moody-Rocky Point Park	2017-08-04	46.3	Yes
Agassiz-Municipal Hall	2017-08-05	58.1	Yes
Burnaby-Kensington Park	2017-08-05	45.6	Yes
Chilliwack-Airport	2017-08-05	37.7	Yes
Hope-Airport	2017-08-05	80.1	Yes
Horseshoe Bay	2017-08-05	36.9	Yes
Mission-School Works Yard	2017-08-05	32.4	Yes
New Westminster-Sapperton Park	2017-08-05	32.1	Yes
N. Vancouver-Mahon Park	2017-08-05	48.4	Yes
N. Vancouver-2nd Narrows	2017-08-05	51.9	Yes
Port Moody-Rocky Point Park	2017-08-05	38	Yes
Abbotsford-Mill Lake	2017-08-06	30.9	Yes
Agassiz-Municipal Hall	2017-08-06	58.1	Yes
Burnaby-Kensington Park	2017-08-06	51.1	Yes
Burnaby South	2017-08-06	31.6	Yes
Chilliwack-Airport	2017-08-06	47.7	Yes
Hope-Airport	2017-08-06	86	Yes
Horseshoe Bay	2017-08-06	39.4	Yes
Langley Central	2017-08-06	29.8	Yes
Mission-School Works Yard	2017-08-06	38.9	Yes
New Westminster–Sapperton Park	2017-08-06	35.4	Yes
N. Vancouver-Mahon Park	2017-08-06	47.2	Yes
N. Vancouver-2nd Narrows	2017-08-06	47	Yes
Pitt Meadows-Meadowlands School	2017-08-06	33.8	Yes
Port Moody-Rocky Point Park	2017-08-06	46.8	Yes

Table II-4 (continued)

Location	Date	Daily Mean ($\mu g/m^3$)	Wildfire Smoke-related Air Quality Advisory?
Abbotsford-Airport	2017-08-07	32	Yes
Abbotsford-Mill Lake	2017-08-07	37.3	Yes
Agassiz-Municipal Hall	2017-08-07	64.4	Yes
Burnaby-Kensington Park	2017-08-07	50	Yes
Burnaby South	2017-08-07	37.6	Yes
Chilliwack-Airport	2017-08-07	56.9	Yes
Hope-Airport	2017-08-07	73.9	Yes
Horseshoe Bay	2017-08-07	44.8	Yes
Langley Central	2017-08-07	37.1	Yes
Mission-School Works Yard	2017-08-07	50.8	Yes
New Westminster-Sapperton Park	2017-08-07	39.6	Yes
North Delta	2017-08-07	35.8	Yes
N. Vancouver-Mahon Park	2017-08-07	53.2	Yes
N. Vancouver-2nd Narrows	2017-08-07	53.1	Yes
Pitt Meadows-Meadowlands School	2017-08-07	41	Yes
Port Moody-Rocky Point Park	2017-08-07	52.4	Yes
Richmond South	2017-08-07	31.8	Yes
Tsawwassen	2017-08-07	29.3	Yes
Richmond-Airport	2017-08-07	29.3	Yes
Abbotsford-Airport	2017-08-08	44	Yes
Abbotsford-Mill Lake	2017-08-08	48.4	Yes
Agassiz-Municipal Hall	2017-08-08	55.9	Yes
Burnaby-Kensington Park	2017-08-08	54.4	Yes
Burnaby-South	2017-08-08	42.7	Yes
Chilliwack-Airport	2017-08-08	54	Yes
Hope-Airport	2017-08-08	55.1	Yes
Horseshoe Bay	2017-08-08	42.1	Yes
Langley Central	2017-08-08	43.2	Yes
Mission-School Works Yard	2017-08-08	53	Yes
New Westminster-Sapperton Park	2017-08-08	49	Yes
North Delta	2017-08-08	42.4	Yes
N. Vancouver-Mahon Park	2017-08-08	58.4	Yes

Table II-4 (continued)

Location	Date	Daily Mean ($\mu g/m^3$)	Wildfire Smoke-related Air Quality Advisory?
N. Vancouver-2nd Narrows	2017-08-08	55.7	Yes
Pitt Meadows-Meadowlands School	2017-08-08	45.4	Yes
Port Moody-Rocky Point Park	2017-08-08	56.2	Yes
Richmond South	2017-08-08	29.8	Yes
Tsawwassen	2017-08-08	29	Yes
Abbotsford-Airport	2017-08-09	41.4	Yes
Abbotsford-Mill Lake	2017-08-09	45.8	Yes
Burnaby-Kensington Park	2017-08-09	56.3	Yes
Burnaby South	2017-08-09	44.8	Yes
Chilliwack-Airport	2017-08-09	51.9	Yes
Hope-Airport	2017-08-09	56	Yes
Horseshoe Bay	2017-08-09	50.7	Yes
Langley Central	2017-08-09	46.4	Yes
Mission-School Works Yard	2017-08-09	57	Yes
North Delta	2017-08-09	40.2	Yes
N. Vancouver Mahon Park	2017-08-09	59.3	Yes
N. Vancouver-2nd Narrows	2017-08-09	60	Yes
Pitt Meadows-Meadowlands School	2017-08-09	47.5	Yes
Port Moody-Rocky Point Park	2017-08-09	57.8	Yes
Richmond South	2017-08-09	36.8	Yes
Tsawwassen	2017-08-09	33.6	Yes
Richmond-Airport	2017-08-09	36.8	Yes
Abbotsford-Airport	2017-08-10	38.2	Yes
Abbotsford-Mill Lake	2017-08-10	42.1	Yes
Burnaby-Kensington Park	2017-08-10	51.5	Yes
Burnaby South	2017-08-10	41.6	Yes
Chilliwack-Airport	2017-08-10	48.8	Yes
Hope-Airport	2017-08-10	58.5	Yes
Horseshoe Bay	2017-08-10	45.5	Yes
Langley Central	2017-08-10	42.3	Yes
Mission-School Works Yard	2017-08-10	52.7	Yes
New Westminster-Sapperton Park	2017-08-10	43.3	Yes

Table II-4 (continued)

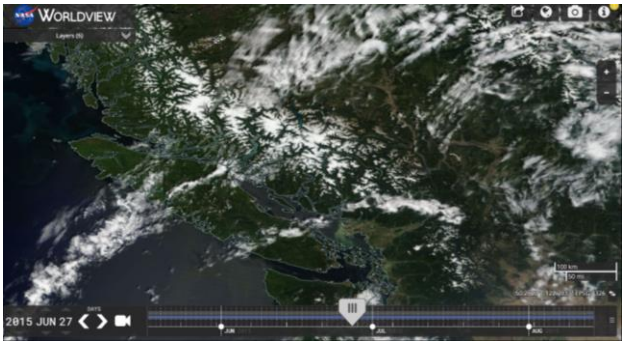
Location	Date	Daily Mean ($\mu g/m^3$)	Wildfire Smoke-related Air Quality Advisory?
North Delta	2017-08-10	39.8	Yes
N. Vancouver-Mahon Park	2017-08-10	56.3	Yes
N. Vancouver-2nd Narrows	2017-08-10	57.4	Yes
Pitt Meadows-Meadowlands School	2017-08-10	46.8	Yes
Port Moody-Rocky Point Park	2017-08-10	54.9	Yes
Richmond South	2017-08-10	32.7	Yes
Tsawwassen	2017-08-10	29.8	Yes
Richmond-Airport	2017-08-10	33.7	Yes
Agassiz- Municipal Hall	2017-08-11	46.3	Yes
Burnaby-Kensington Park	2017-08-11	29.9	Yes
Chilliwack-Airport	2017-08-11	31.3	Yes
Hope-Airport	2017-08-11	41.6	Yes
Horseshoe Bay	2017-08-11	29.3	Yes
Mission-School Works Yard	2017-08-11	33.9	Yes
N. Vancouver-Mahon Park	2017-08-11	32	Yes
N. Vancouver-2nd Narrows	2017-08-11	37.1	Yes
Pitt Meadows-Meadowlands School	2017-08-11	29.7	Yes
Port Moody-Rocky Point Park	2017-08-11	36.6	Yes
Agassiz- Municipal Hall	2017-08-29	31	Yes
Chilliwack-Airport	2017-08-29	28.2	Yes
Hope-Airport	2017-08-29	28.5	Yes
Hope-Airport	2017-09-04	29.3	Yes
Abbotsford-Airport	2017-09-05	33.1	Yes
Abbotsford-Mill Lake	2017-09-05	31.3	Yes
Agassiz-Municipal Hall	2017-09-05	41.1	Yes
Burnaby-Kensington Park	2017-09-05	35.8	Yes
Burnaby-South	2017-09-05	29.2	Yes
Chilliwack-Airport	2017-09-05	40	Yes
Hope-Airport	2017-09-05	46.2	Yes
Mission-School Works Yard	2017-09-05	34.3	Yes
New Westminster Sapperton Park	2017-09-05	30.3	Yes
North Delta	2017-09-05	29.8	Yes

Table II-4 (continued)

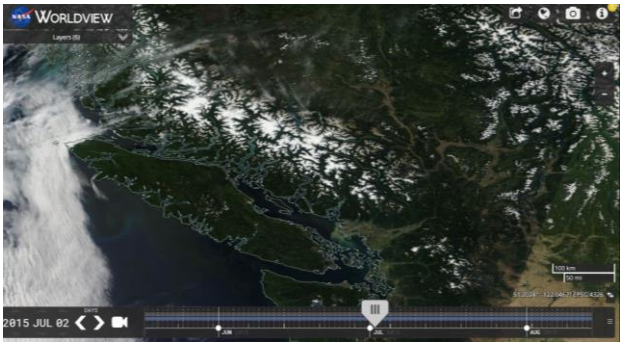
Location	Date	Daily Mean ($\mu g/m^3$)	Wildfire Smoke-related Air Quality Advisory?
N. Vancouver-Mahon Park	2017-09-05	41.6	Yes
N. Vancouver-2nd Narrows	2017-09-05	33.2	Yes
Pitt Meadows-Meadowlands School	2017-09-05	32.1	Yes
Port Moody-Rocky Point Park	2017-09-05	33	Yes
Abbotsford-Airport	2017-09-06	32.4	Yes
Abbotsford-Mill Lake	2017-09-06	37	Yes
Agassiz-Municipal Hall	2017-09-06	56.9	Yes
Burnaby-Kensington Park	2017-09-06	44.3	Yes
Burnaby-South	2017-09-06	31	Yes
Chilliwack-Airport	2017-09-06	57.4	Yes
Hope-Airport	2017-09-06	87.7	Yes
Horseshoe Bay	2017-09-06	43.9	Yes
Langley Central	2017-09-06	33.3	Yes
Mission-School Works Yard	2017-09-06	47	Yes
New Westminster-Sapperton Park	2017-09-06	43.6	Yes
North Delta	2017-09-06	34.4	Yes
N. Vancouver-Mahon Park	2017-09-06	62	Yes
N. Vancouver-2nd Narrows	2017-09-06	51	Yes
Pitt Meadows-Meadowlands School	2017-09-06	40.2	Yes
Port Moody-Rocky Point Park	2017-09-06	45.1	Yes
Surrey East	2017-09-06	31.8	Yes
Abbotsford-Mill Lake	2017-09-07	28.8	Yes
Agassiz- Municipal Hall	2017-09-07	46.6	Yes
Burnaby-Kensington Park	2017-09-07	39.4	Yes
Burnaby-South	2017-09-07	31.9	Yes
Chilliwack-Airport	2017-09-07	42.8	Yes
Hope-Airport	2017-09-07	56.6	Yes
Horseshoe Bay	2017-09-07	39.5	Yes
Mission-School Works Yard	2017-09-07	38	Yes
New Westminster-Sapperton Park	2017-09-07	38.2	Yes
North Delta	2017-09-07	31.9	Yes

Table II-4 (continued)

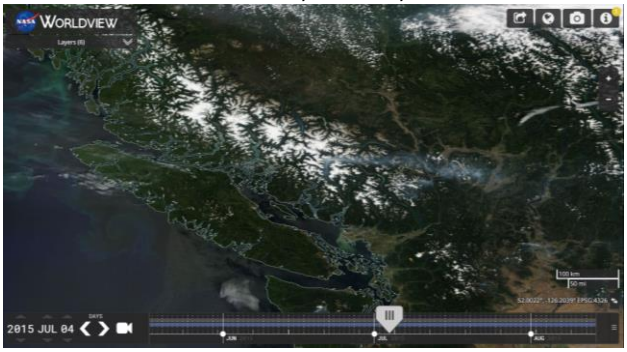
Location	Date	Daily Mean ($\mu g/m^3$)	Wildfire Smoke-related Air Quality Advisory?
N. Vancouver-Mahon Park	2017-09-07	41.9	Yes
N. Vancouver-2nd Narrows	2017-09-07	42.3	Yes
Pitt Meadows-Meadowlands School	2017-09-07	35.4	Yes
Port Moody-Rocky Point Park	2017-09-07	41.5	Yes
Surrey East	2017-09-07	29.1	Yes
Richmond-Airport	2017-09-07	28.6	Yes



a. NASA Worldview, Jun. 27, 2015



b. NASA Worldview, Jul. 2, 2015



c. NASA Worldview, Jul. 4, 2015

d. NASA Worldview, Jul. 6, 2015

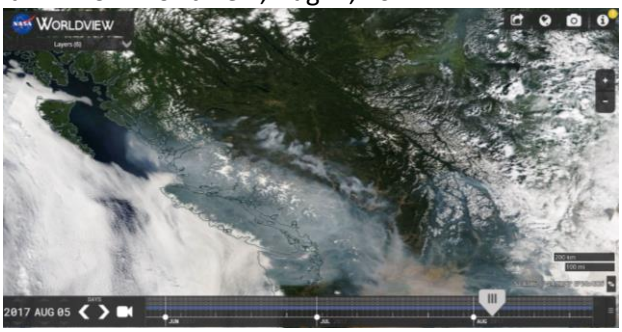
e. NASA Worldview, Jul. 8, 2015

f. NASA Worldview, Jul. 9, 2015

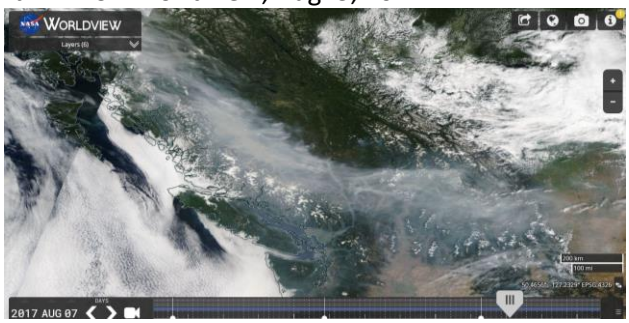
Figure II-1. Satellite images showing no visible wildfire smoke over southwest coast on Jun. 27 and Jul. 2 and 4, 2015 (Figs. a-c) and showing grey plume associated with wildfire smoke on Jul. 6, 8 and 9, 2015 (Figs. d-f). Source of images: NASA Worldview at: https://worldview.earthdata.nasa.gov/.

a. NASA Worldview, Aug. 1, 2017

b. NASA Worldview, Aug. 3, 2017



c. NASA Worldview, Aug. 5, 2017



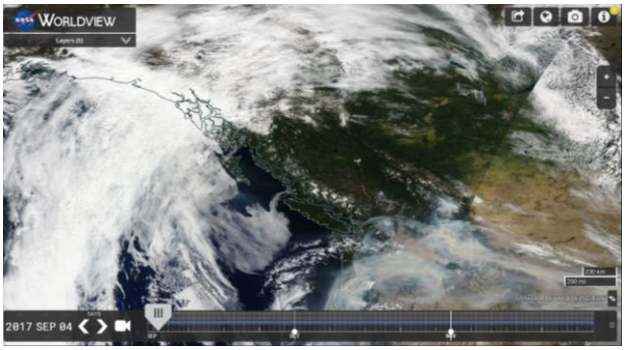
d. NASA Worldview, Aug. 7, 2017

e. NASA Worldview, Aug. 9, 2017

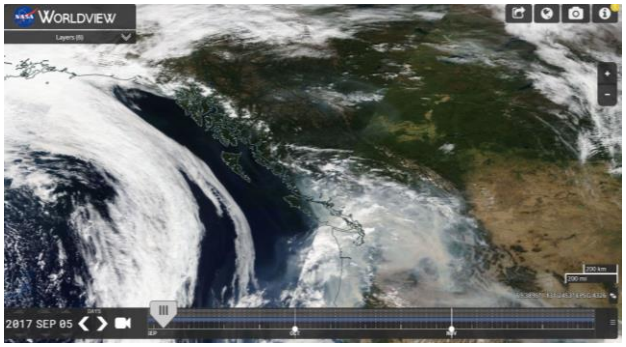
f. NASA Worldview, Aug. 11, 2017

g. NASA Worldview, Aug. 29, 2017

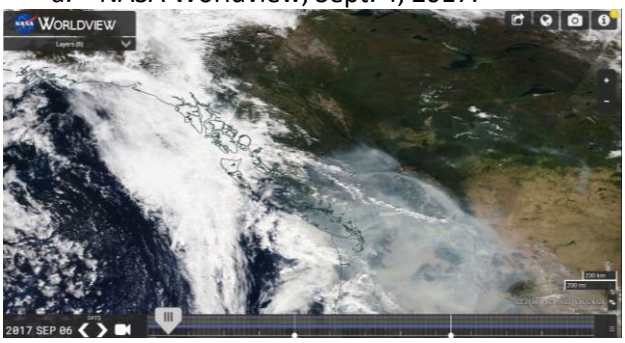
Figure II-2. Satellite images covering Aug. 1-11 and Aug. 29, 2017, showing wildfire smoke (grey plumes) over the southwest coast, including the LFV Air Zone. Source of images: NASA Worldview at: https://worldview.earthdata.nasa.gov/.



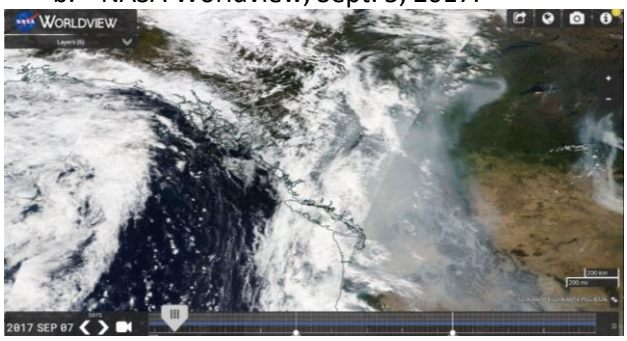
a. NASA Worldview, Sept. 4, 2017.



b. NASA Worldview, Sept. 5, 2017.



c. NASA Worldview, Sept. 6, 2017.



d. NASA Worldview, Sept. 7, 2017.

Figure II-3. Satellite images covering Sept. 4-7 2017, showing wildfire smoke (grey plumes) over the southwest coast, including the LFV Air Zone. Source of images: NASA Worldview at: https://worldview.earthdata.nasa.gov/.

Appendix III – Supporting analysis of wildfire influences on ozone levels in the Lower Fraser Valley Air Zone (2015-2017)

This appendix describes the analysis performed to support the determination of whether the presence of wildfire smoke influenced ozone levels in the Lower Fraser Valley Air Zone for the 2015-2017 reporting period.

Using the analysis presented in Appendix I and Appendix II, dates where wildfire smoke was present in the Lower Fraser Valley Air Zone were identified using analysis of satellite data, air quality advisories and $PM_{2.5}$ concentrations measured at ambient air quality stations in the Lower Fraser Valley air quality monitoring network. Table III-1 outlines dates for which it was determined that wildfire smoke was present in the air zone and the 8-hour ozone concentration exceeded the CAAQS level of 63 ppb. The dates in Table III-1 were each assessed to determine whether ozone was enhanced as a result of wildfire smoke.

Table III-1. Dates for which 24-hour $PM_{2.5}$ concentrations were influenced by wildfires outside the region.

Date	End Hour	8-Hr Daily Max O_3 (ppb)	24-hr $PM_{2.5}$ ($\mu g/m^3$)	Max Temp (^oC)	Air Quality Advisory in Effect	Figure Reference
2015-07-06	19:00	64.5	28.4	29.6	Due to PM from wildfires outside region	Figures III-4 to III-6
2015-07-08	19:00	75.6	31.0	30.9	Due to PM from wildfires outside region	Figures III-7 to III-9
2015-07-09	19:00	77.5	35.8	31.2	Due to PM from wildfires outside region	Figures III-10 to III-12
2017-08-03	19:00	78.4	89.3	31.5	Due to PM from interior wildfires	Figures III-13 to III-15
2017-08-07	19:00	72.3	73.9	29.3	Due to PM from interior wildfires	Figures III-16 to III-18
2017-08-10	19:00	78.8	58.5	31.4	Due to PM from interior wildfires + ozone	Figures III-19 to III-21
2017-08-11	19:00	68.9	41.6	30.3	Due to PM from interior wildfires + ozone	Figures III-22 to III-24
2017-08-29	20:00	75.9	28.5	32.1	Due to PM from PNW wildfires + ozone	Figures III-1 to III-3

Methodology for Determination of Wildfire Smoke Influence on Ozone Concentrations[13]

This section outlines the methodology used to determine whether wildfire smoke influenced ozone concentrations, for the dates listed in Table III-1. To illustrate the method, data for August 29, 2017 is shown in Figures III-1 to III-3 as an example.

Figure III-1 shows a set of diurnal curves derived from the data record at Metro Vancouver's Second Narrows air quality monitoring station from 2009-2018 for the summer months (June-September, inclusive). For each hour of the day during this period, the data were ranked and a set of percentiles were chosen so that a curve could be developed to represent a typical diurnal pattern of ozone. For example, the 50th percentile curve is created by finding the 50th percentile for each hour of the day based on all of the summer hours between 2009-2018.

Using the percentile curves, a specific day can be compared to the historical percentiles and if these days are above a 98th percentile, it could be considered a historically high day for that parameter. The upper, middle and bottom plots show data for ozone, $PM_{2.5}$ and temperature. In the upper plot of Figure III-1, the black line shows hourly concentrations for ozone recorded on August 29, 2017 at the Second Narrows station. Much of the curve during the daytime is well above the 98th percentile, indicating that it was a historically high day for ozone at this location. In fact, prior to 2017, the Second Narrows station had not reached these ozone concentrations since 1990. In addition, ozone concentrations on August 29, 2017 peaked about one to two hours earlier than what is shown by the 98th percentile curve, reflecting unusual conditions.

$PM_{2.5}$ concentrations on August 29, 2017 (middle plot of Figure III-1) were also elevated on this day, suggesting the influence of wildfire smoke.[14] Temperature readings on the same day (bottom plot of Figure III-1) were not high compared to historical levels, particularly in the mid-afternoon when the highest ozone levels are typically observed. Temperature is an indicator of solar radiation, which is a key factor in ozone chemistry. Lower temperatures than expected for high-ozone days suggests that other factors may have influenced ozone levels. Paired with elevated $PM_{2.5}$ levels, this suggests that wildfire smoke contributed to enhanced ozone levels on this day.

[13] Methodology, analyses and plots prepared by K. Howe, Metro Vancouver.

[14] As a point of reference, in its *2016 Lower Fraser Valley Air Quality Monitoring Report*, Metro Vancouver showed that summertime diurnal average $PM_{2.5}$ concentrations across the region did not exceed 12 $\mu g/m^3$ in 2016 (a year low in wildfire impacts). Report available at: http://www.metrovancouver.org/services/air-quality/AirQualityPublications/2016-LFVAQMonitoringReport.pdf).

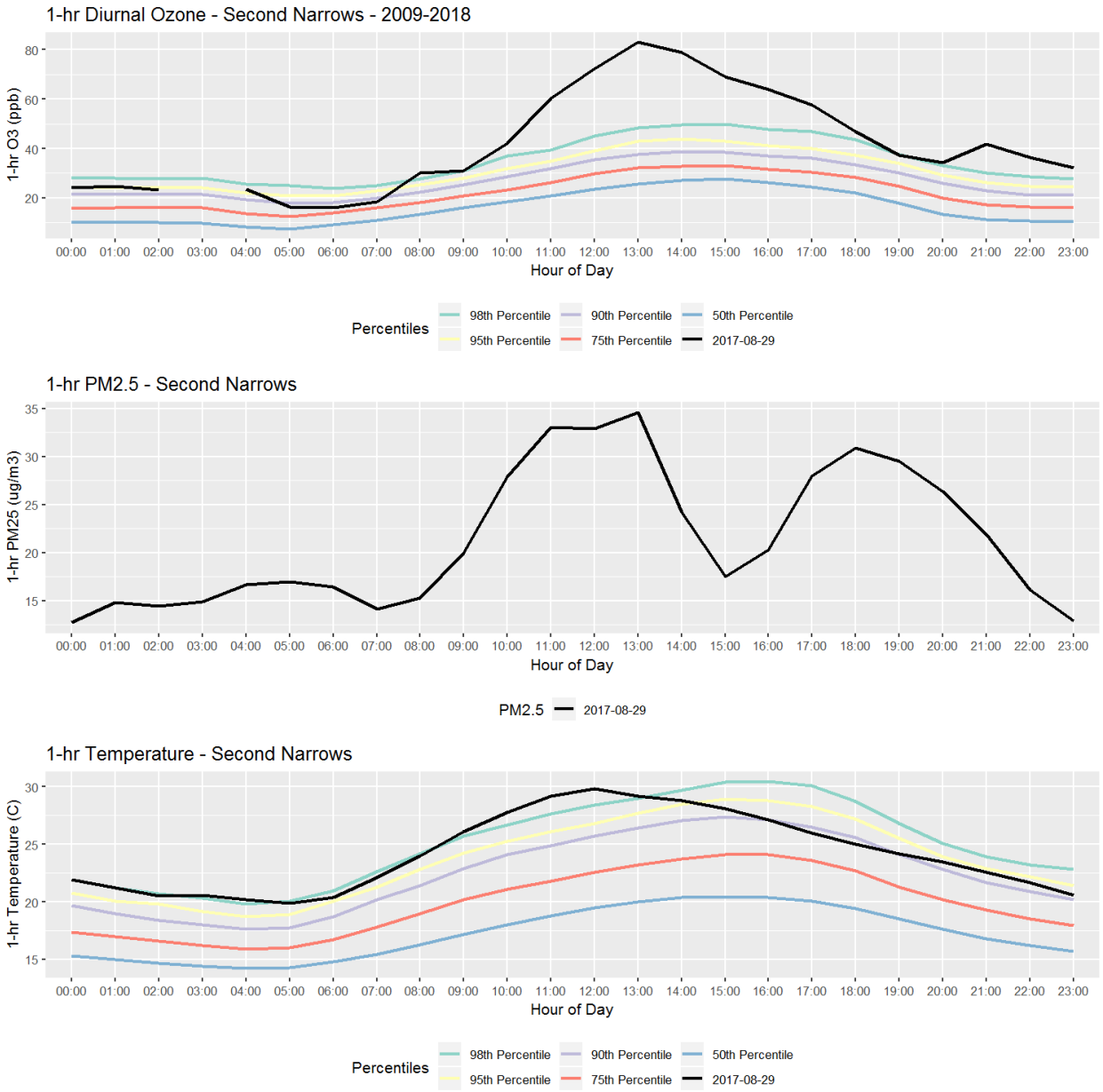


Figure III-1. Historical diurnal plots of ozone (upper) and temperature (lower) and diurnal plot of $PM_{2.5}$ concentrations (middle) recorded at Second Narrows station in North Vancouver on August 29, 2017.

Figure III-2 shows diurnal curves for August 29, 2017 at the Downtown Vancouver air quality monitoring station at Robson Square. This station only records ozone (see 1st chart), so the $PM_{2.5}$ (see 2nd chart) and temperature (see 3rd chart) measurements shown are from the Second Narrows station (7 km to the northeast). Ozone on August 29, 2017 was historically high at this station.

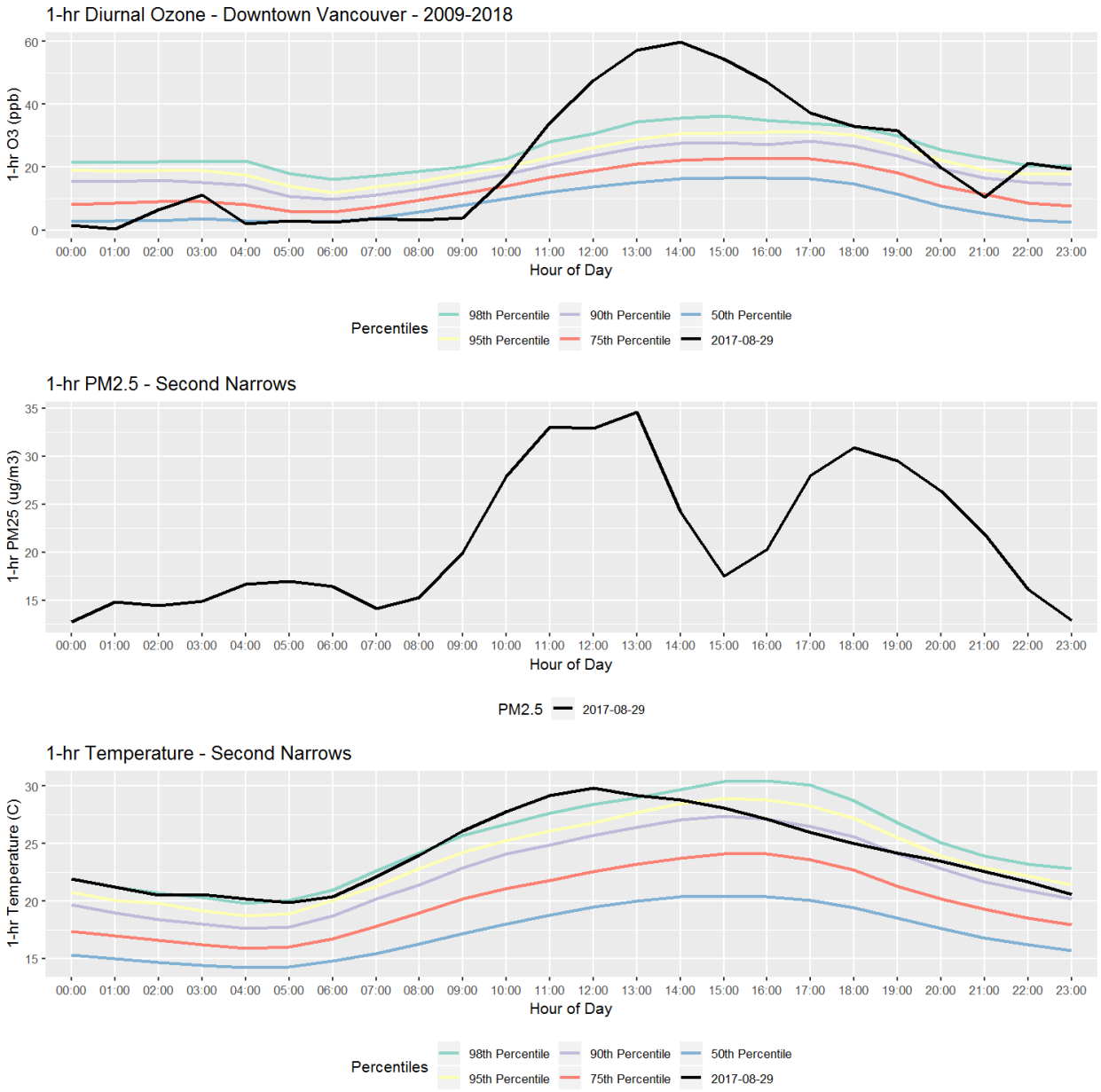


Figure III-2. Historical diurnal plots of ozone (upper) and temperature (lower) and diurnal plot of $PM_{2.5}$ concentrations (middle) recorded at the downtown Vancouver station and Second Narrows station in North Vancouver on August 29, 2017.

Figure III-3 shows diurnal curves for August 29, 2017 at the Hope air quality monitoring station, which is operated by Metro Vancouver on behalf of the Fraser Valley Regional District. Similar to the Second Narrows plots (Figure III-2), smoke was present on the day (see 2nd chart) and ozone was above the 98th percentile for the period between 2009 and 2018 (see 1st chart). Temperatures were not historically high on this day (see 3rd chart).

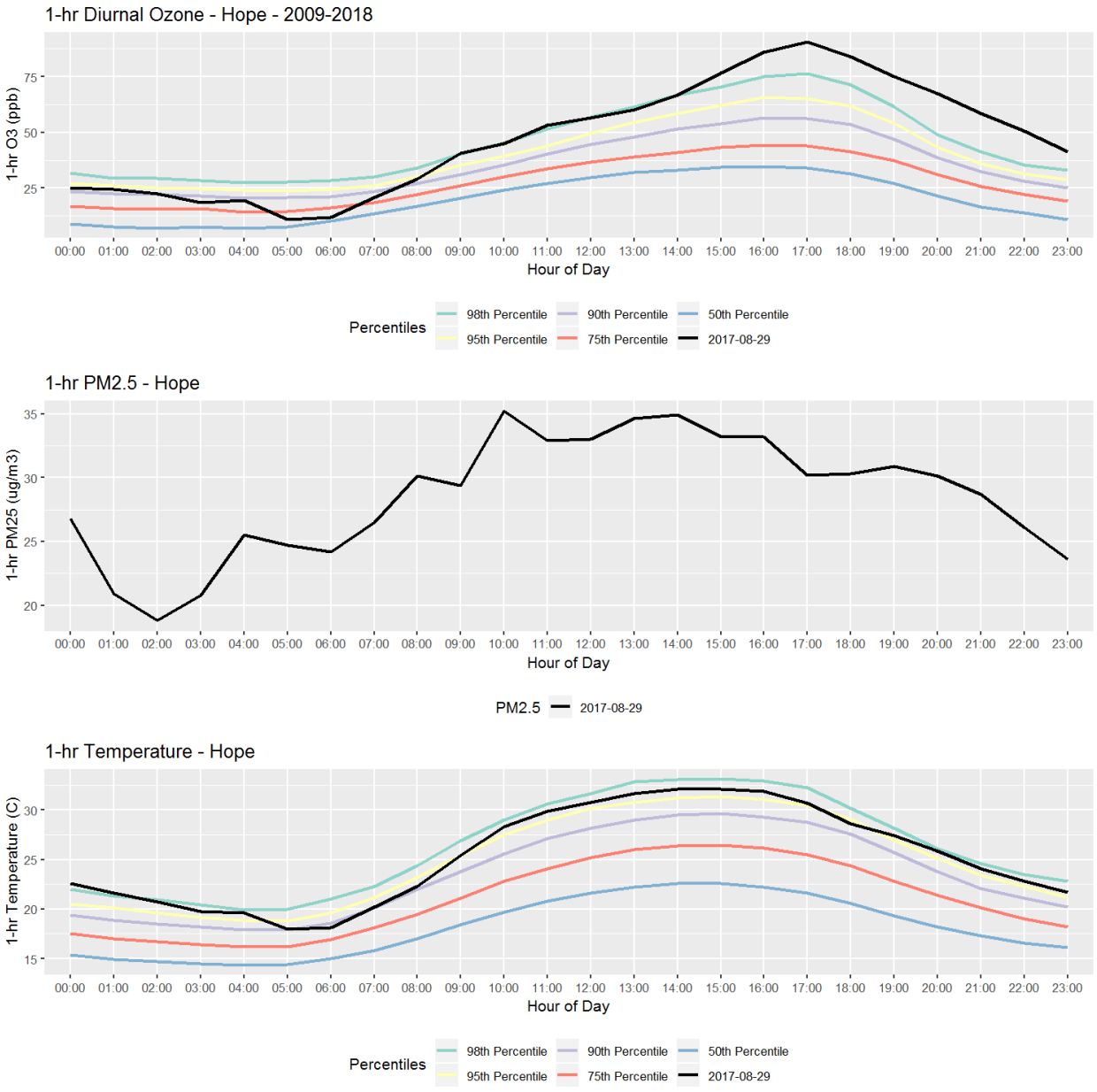


Figure III-3. Historical diurnal plots of ozone (upper) and temperature (lower) and diurnal plot of $PM_{2.5}$ concentrations (middle) recorded at Hope on August 29, 2017.

Taken together, the above factors (i.e., historically high ozone concentrations, the region-wide presence of smoke, and temperatures that were not historically high) indicate that the presence of wildfire smoke was the likely cause of enhanced ozone formation at each of these locations on August 29, 2017.

Analysis for Remaining Dates

This analysis was conducted for the remaining dates in Table III-1 and the results of these analyses are presented in Figures III-4 to III-24.

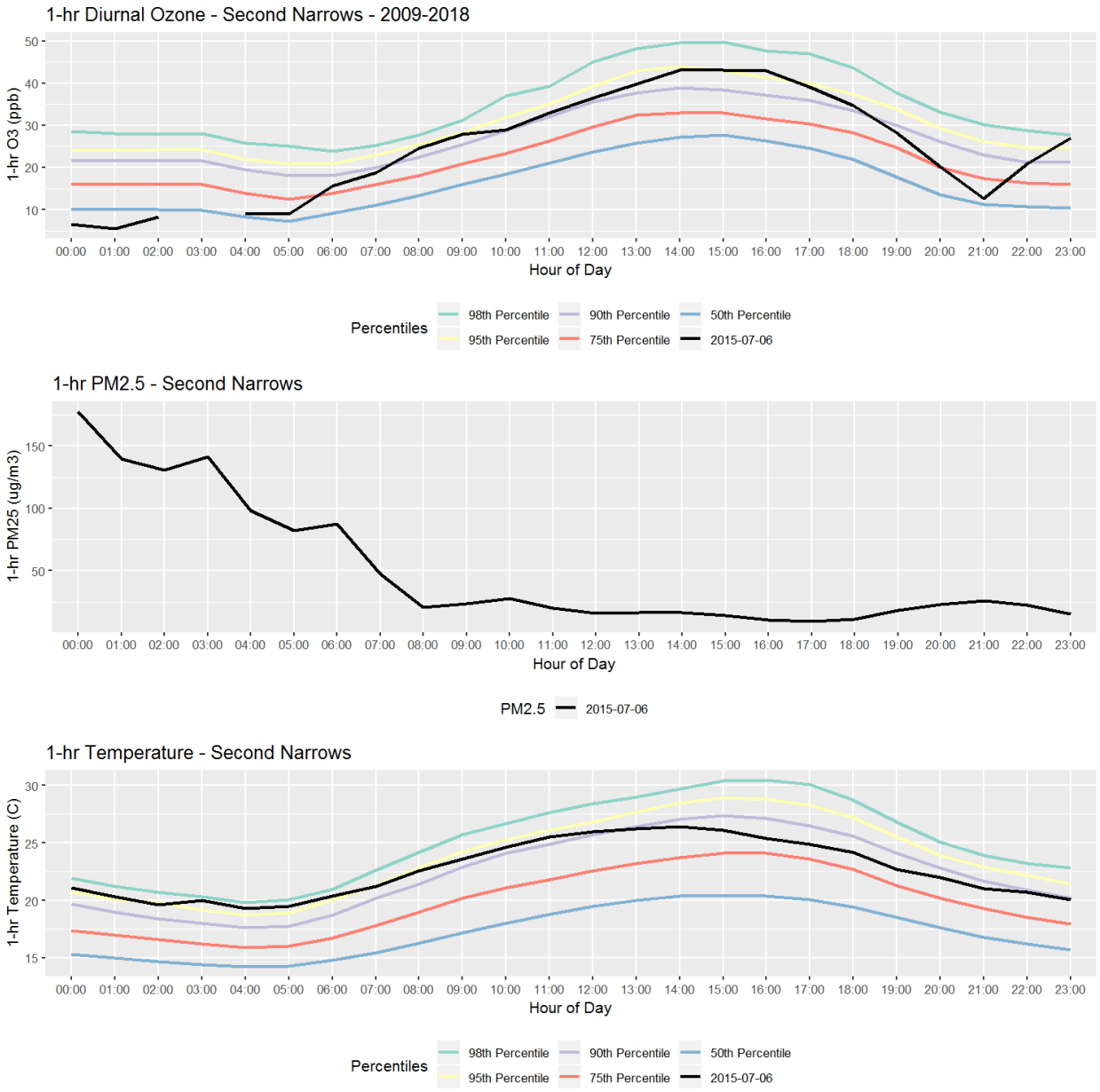


Figure III-4. Historical diurnal plots of ozone (upper) and temperature (lower) and diurnal plot of $PM_{2.5}$ concentration (middle) recorded at Second Narrows station in North Vancouver on July 6, 2015.

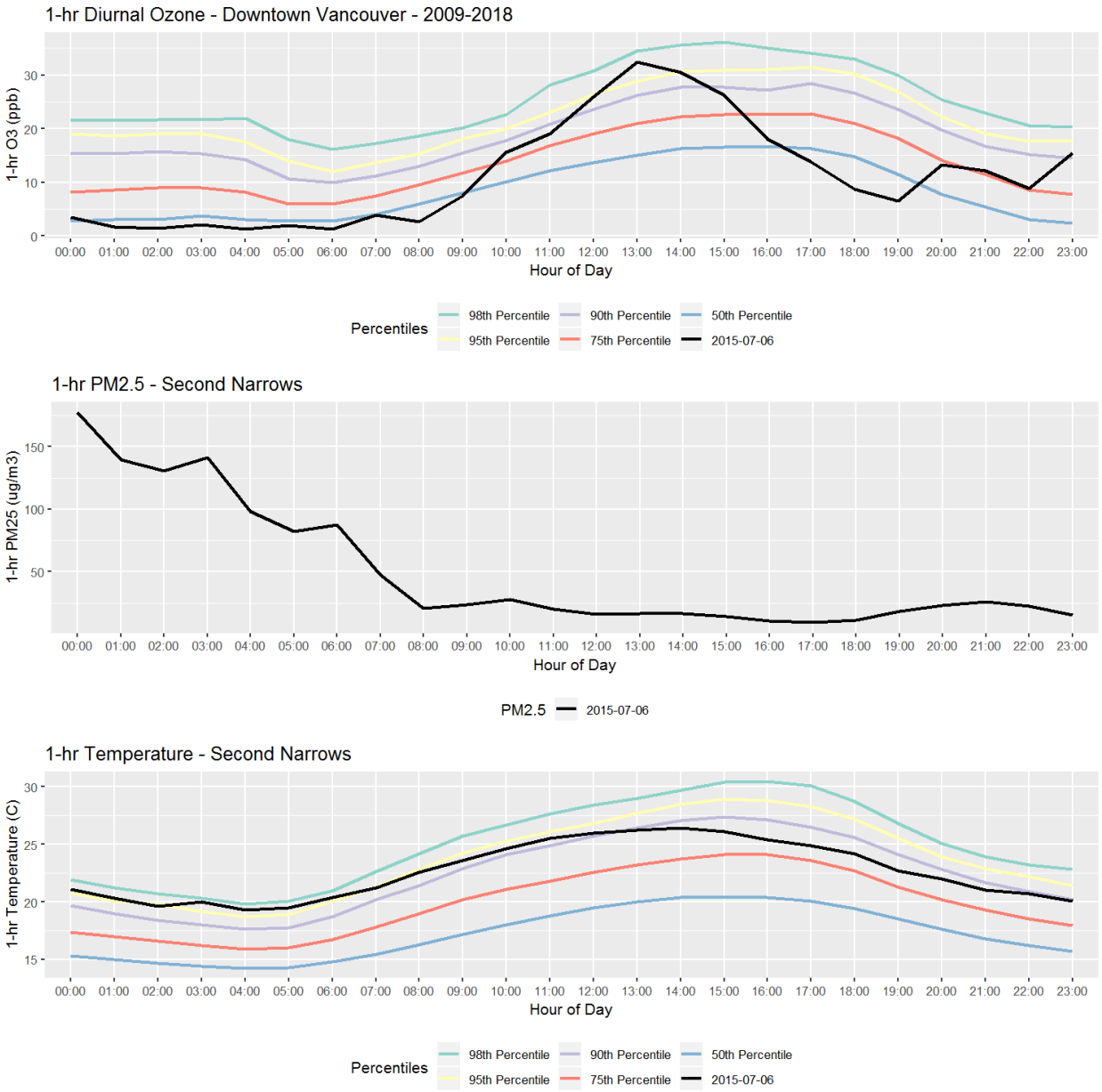


Figure III-5. Historical diurnal plots of ozone (upper) and temperature (lower) and diurnal plot of $PM_{2.5}$ concentrations (middle) recorded at the downtown Vancouver station and Second Narrows station in North Vancouver on July 6, 2015.

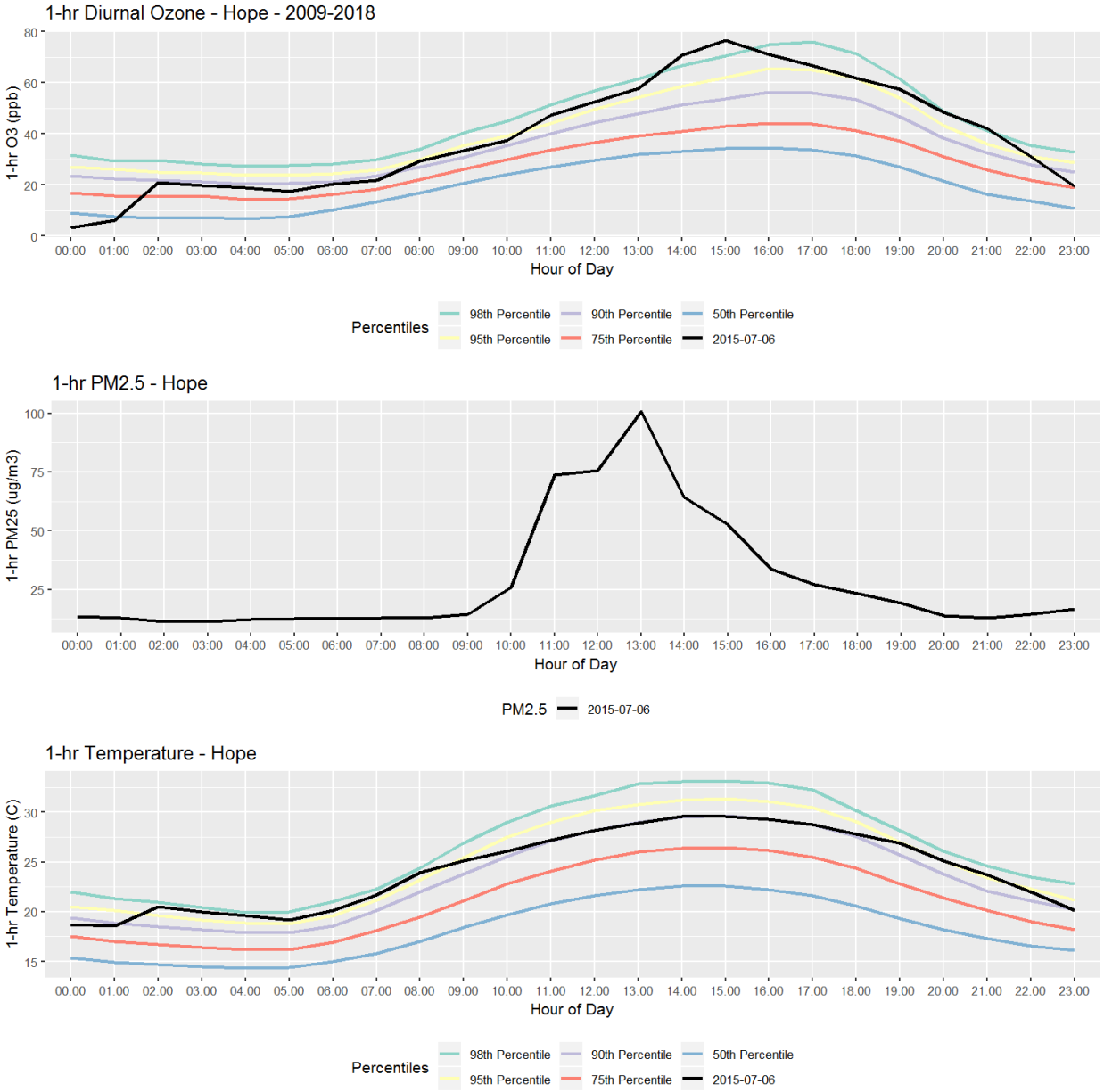


Figure III-6. Historical diurnal plots of ozone (upper) and temperature (lower) and diurnal plot of $PM_{2.5}$ concentrations (middle) recorded at Hope on July 6, 2015.

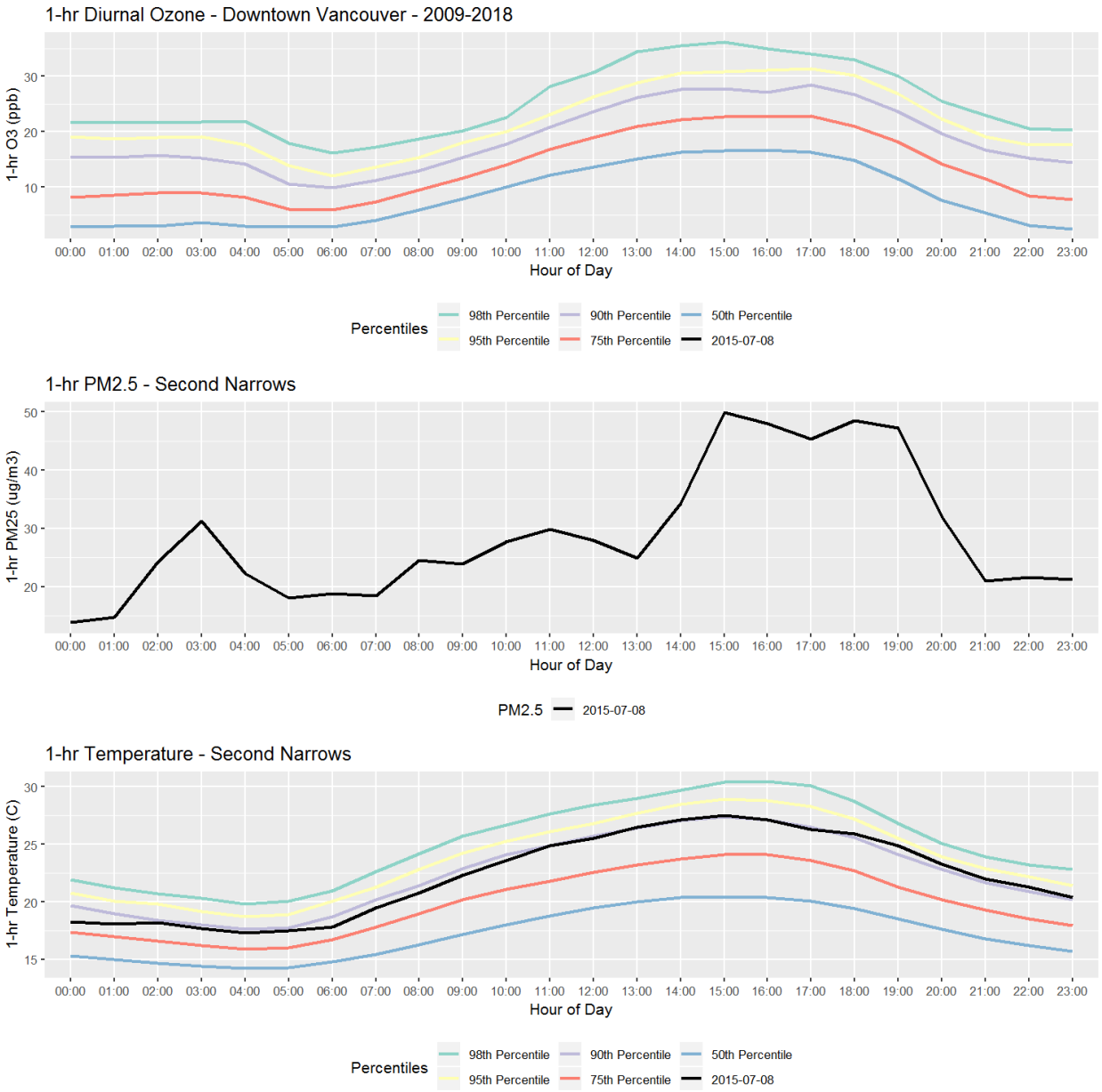


Figure III-7. Historical diurnal plots of ozone (upper) and temperature (lower) and diurnal plot of $PM_{2.5}$ concentrations (middle) recorded at the downtown Vancouver station and Second Narrows station in North Vancouver on July 8, 2015. Note: Ozone data from the downtown Vancouver station was unavailable on July 8, 2015.

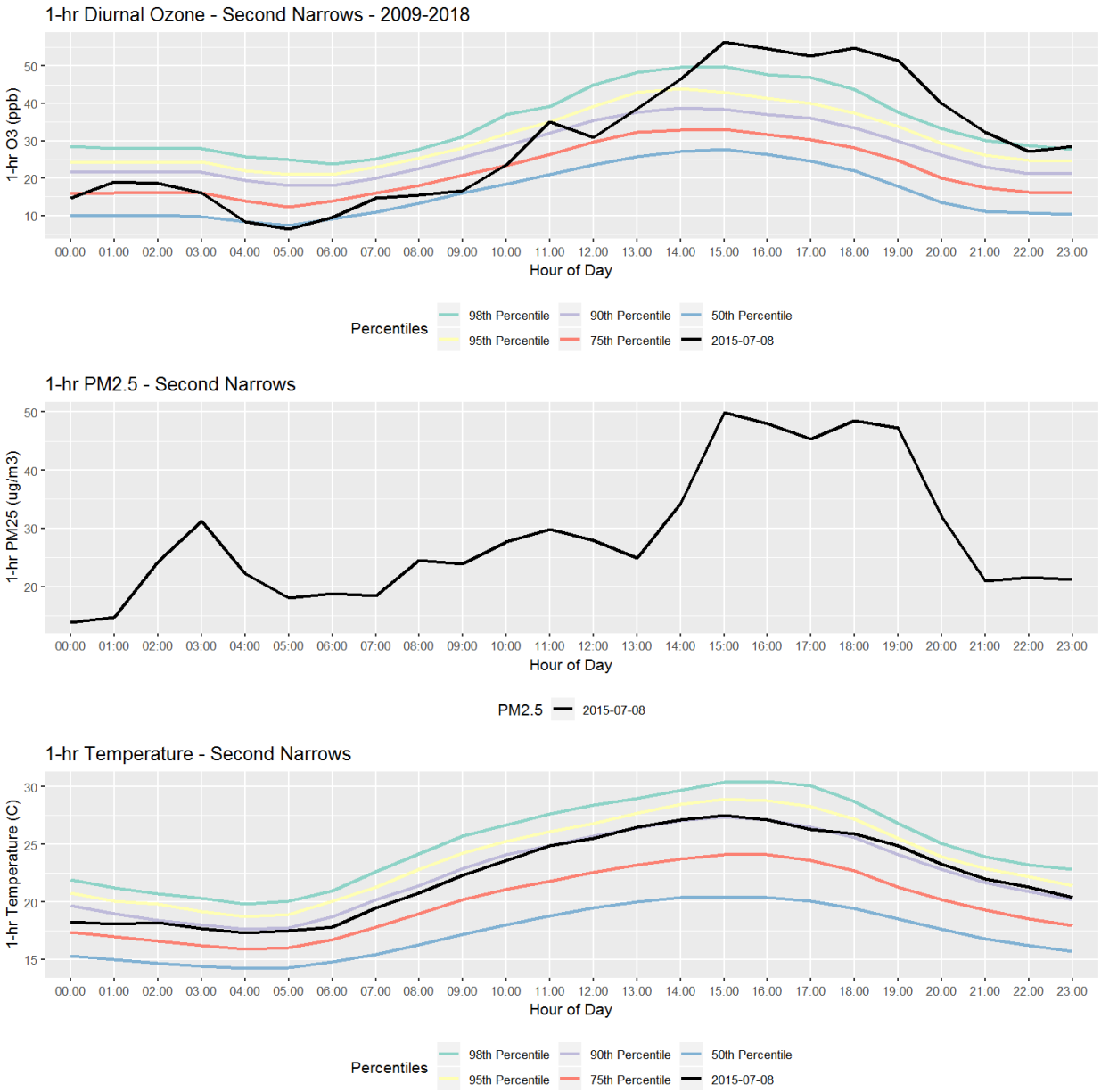


Figure III-8. Historical diurnal plots of ozone (upper) and temperature (lower) and diurnal plot of $PM_{2.5}$ concentrations (middle) recorded at Second Narrows station in North Vancouver on July 8, 2015.

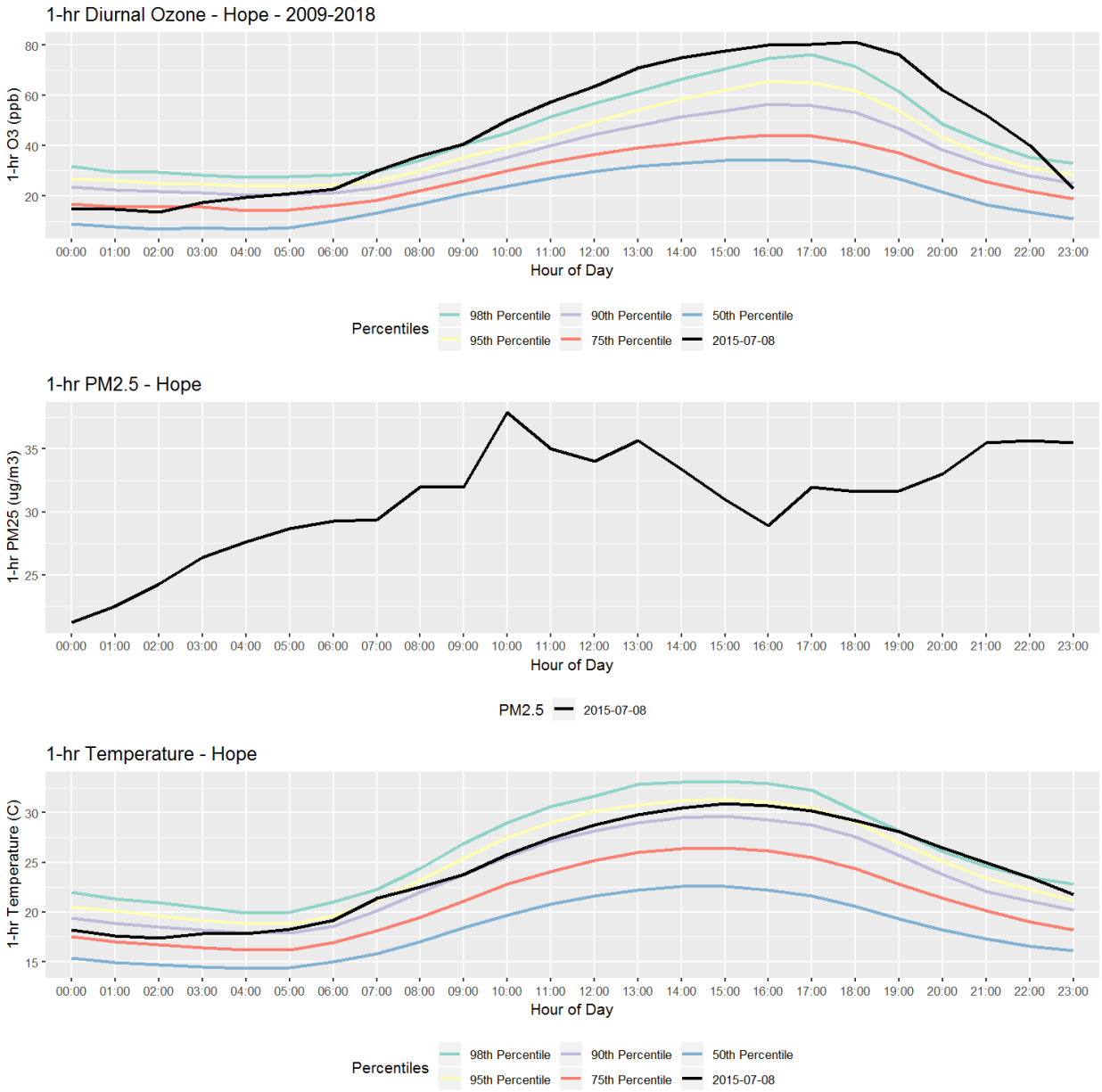


Figure III-9. Historical diurnal plots of ozone (upper) and temperature (lower) and diurnal plot of $PM_{2.5}$ concentrations (middle) recorded at Hope on July 8, 2015.

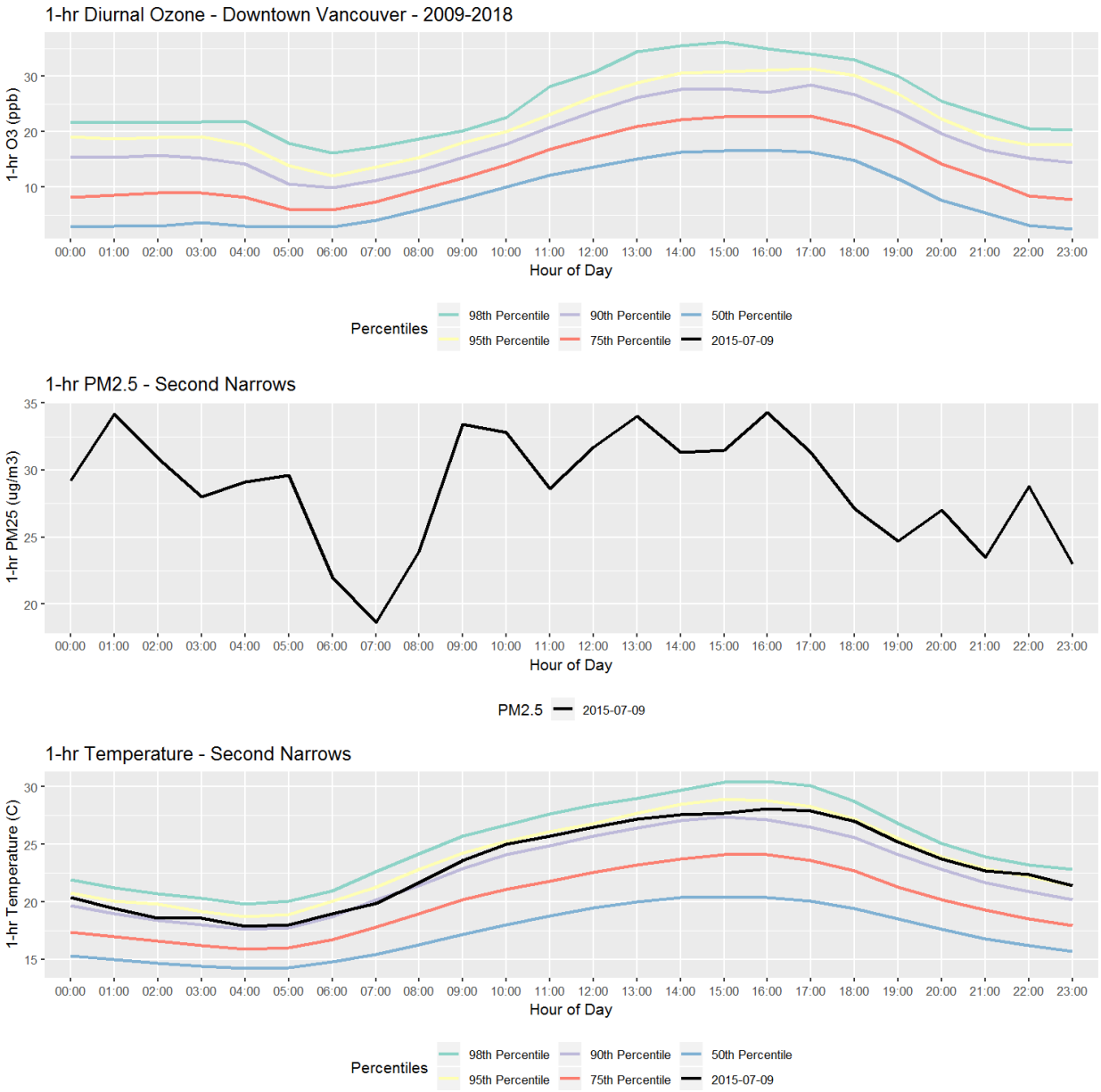


Figure III-10. Historical diurnal plots of ozone (upper) and temperature (lower) and diurnal plots of $PM_{2.5}$ concentrations (middle) recorded at the downtown Vancouver station and Second Narrows station in North Vancouver on July 9, 2015. Note: Ozone data from the downtown Vancouver station was unavailable on July 9, 2015.

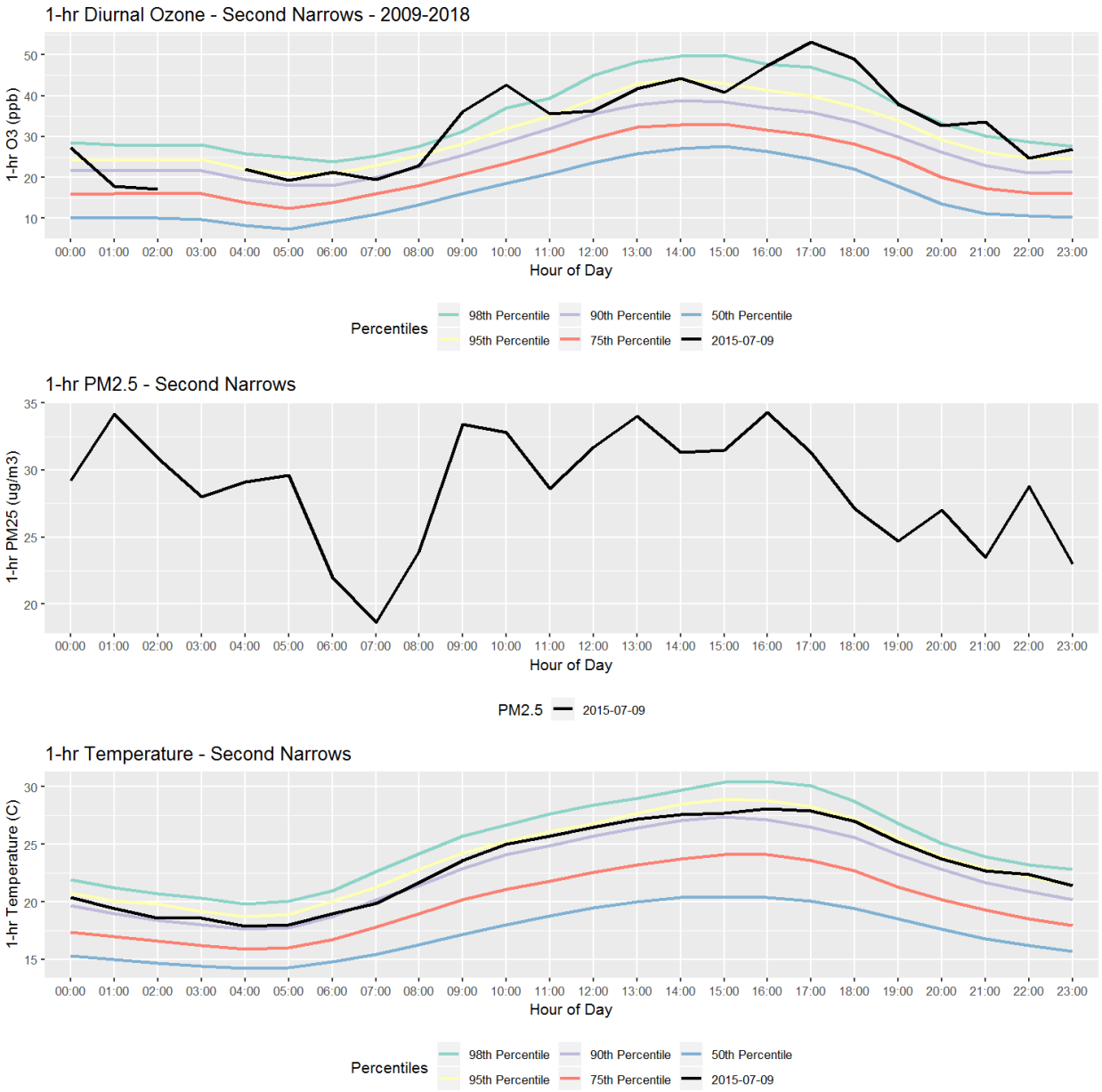


Figure III-11. Historical diurnal plots of ozone (upper) and temperature (lower) and diurnal plot of $PM_{2.5}$ concentrations (middle) recorded at Second Narrows station in North Vancouver on July 9, 2015.

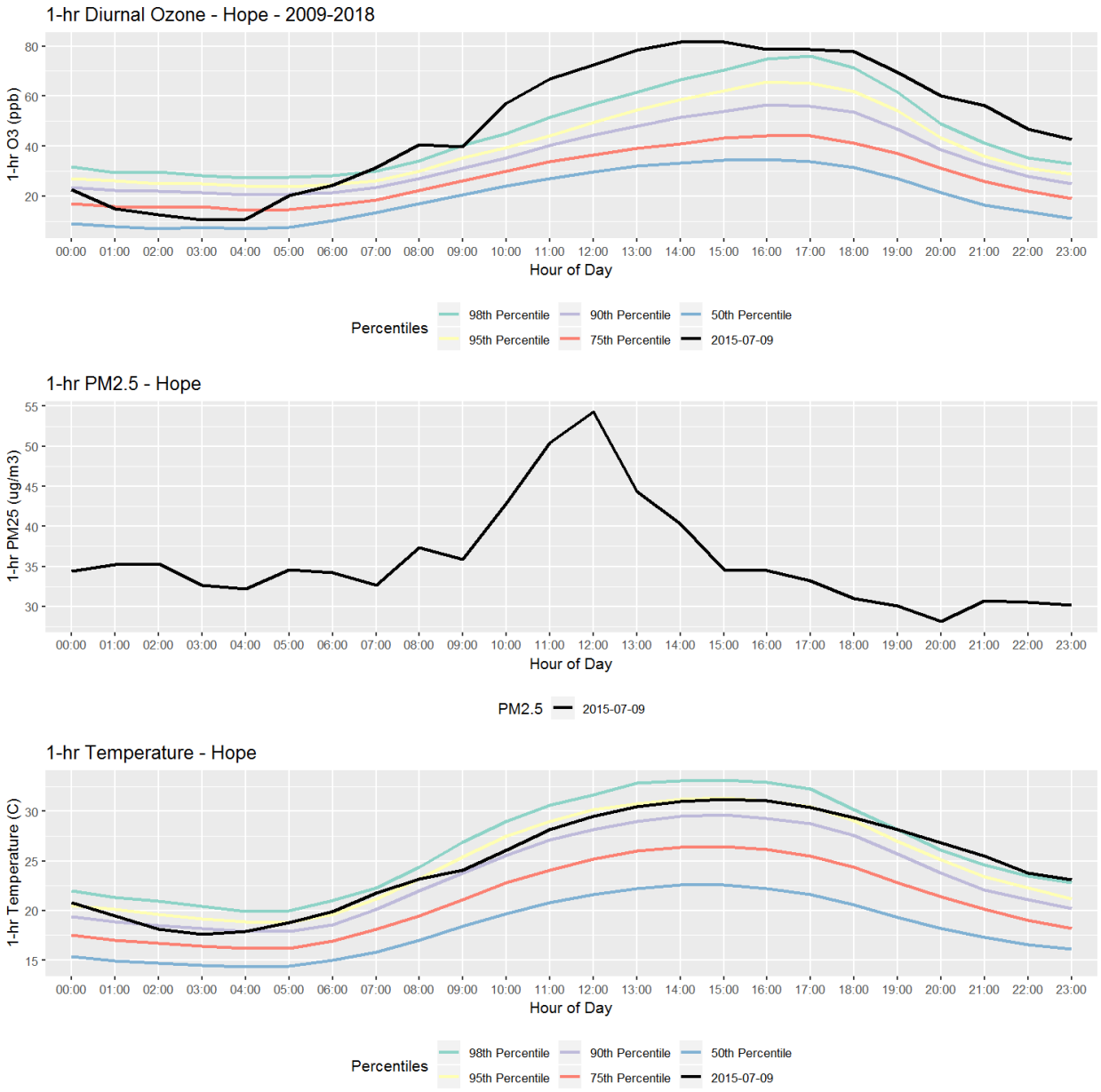


Figure III-12. Historical diurnal plots for ozone (upper) and temperature (lower) and diurnal plot of $PM_{2.5}$ concentrations (middle) recorded at Hope on July 9, 2015.

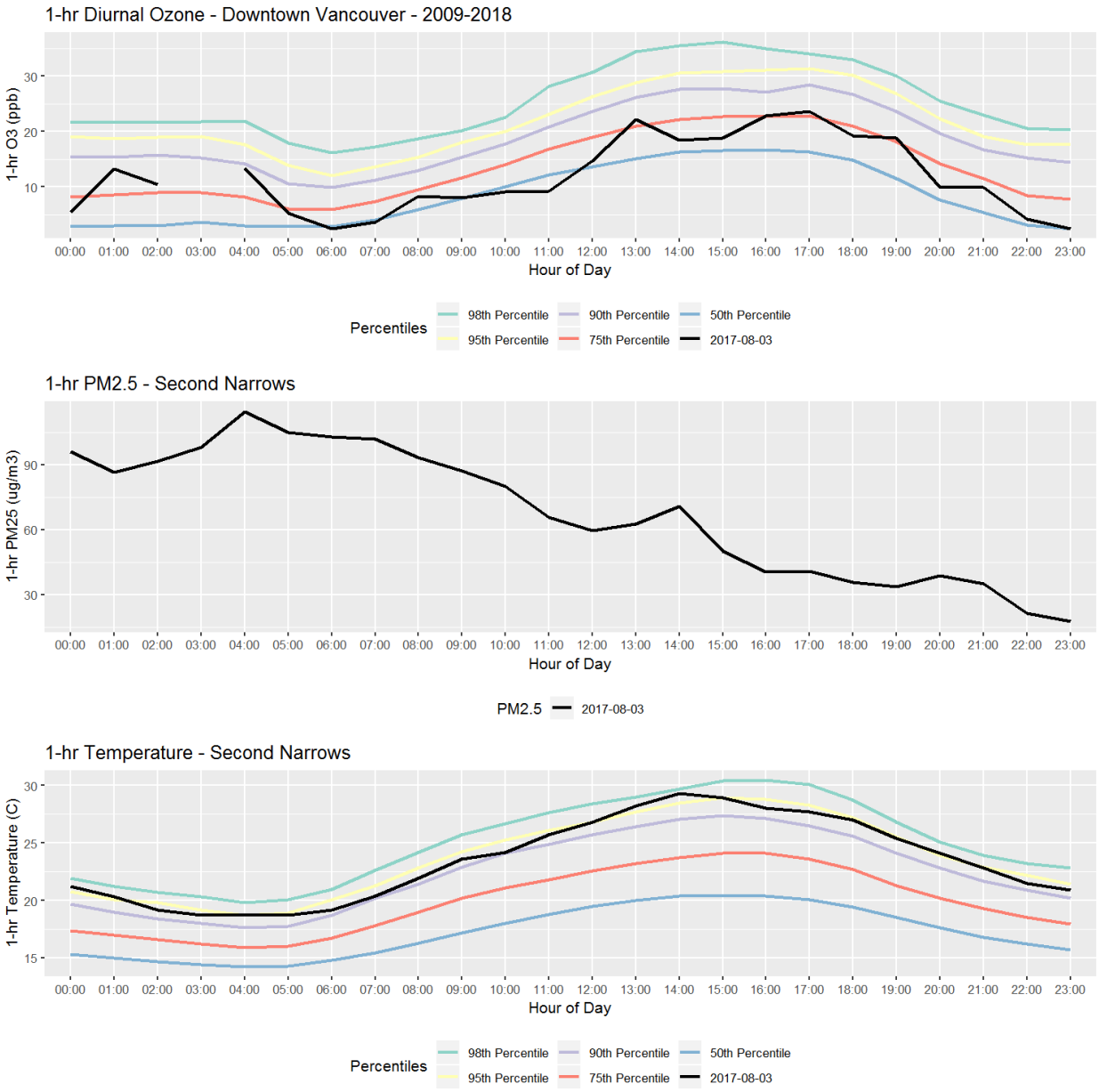


Figure III-13. Historical diurnal plots of ozone (upper) and temperature (lower) and diurnal plot of $PM_{2.5}$ concentrations (middle) recorded at the downtown Vancouver station and Second Narrows station in North Vancouver on August 3, 2017.

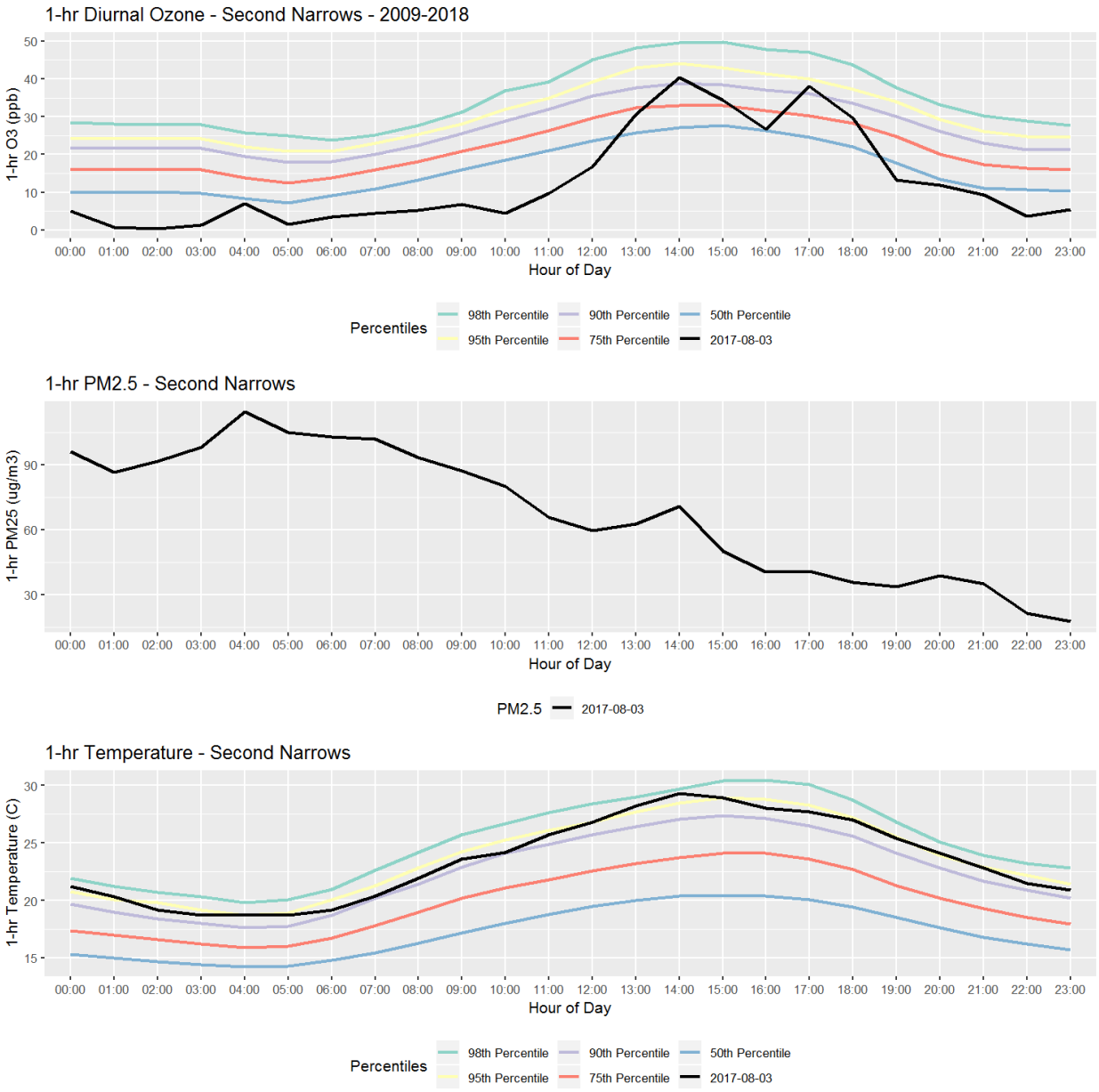


Figure III-14. Historical diurnal plots of ozone (upper) and temperature (lower) and diurnal plot of $PM_{2.5}$ concentrations (middle) recorded at Second Narrows station in North Vancouver on August 3, 2017.

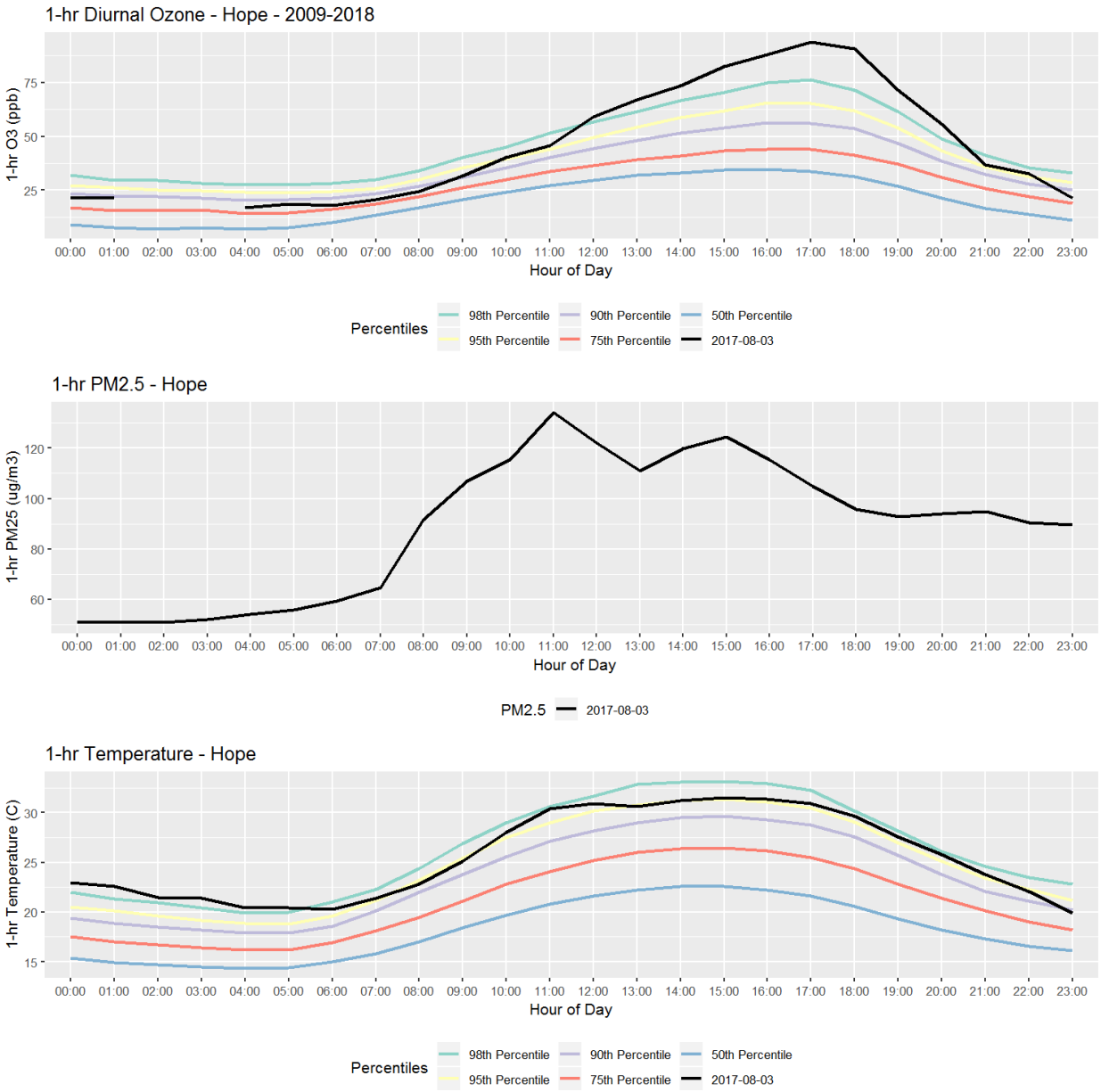


Figure III-15. Historical diurnal plots of ozone (upper) and temperature (lower) and diurnal plot of $PM_{2.5}$ concentrations (middle) recorded at Hope on August 3, 2017.

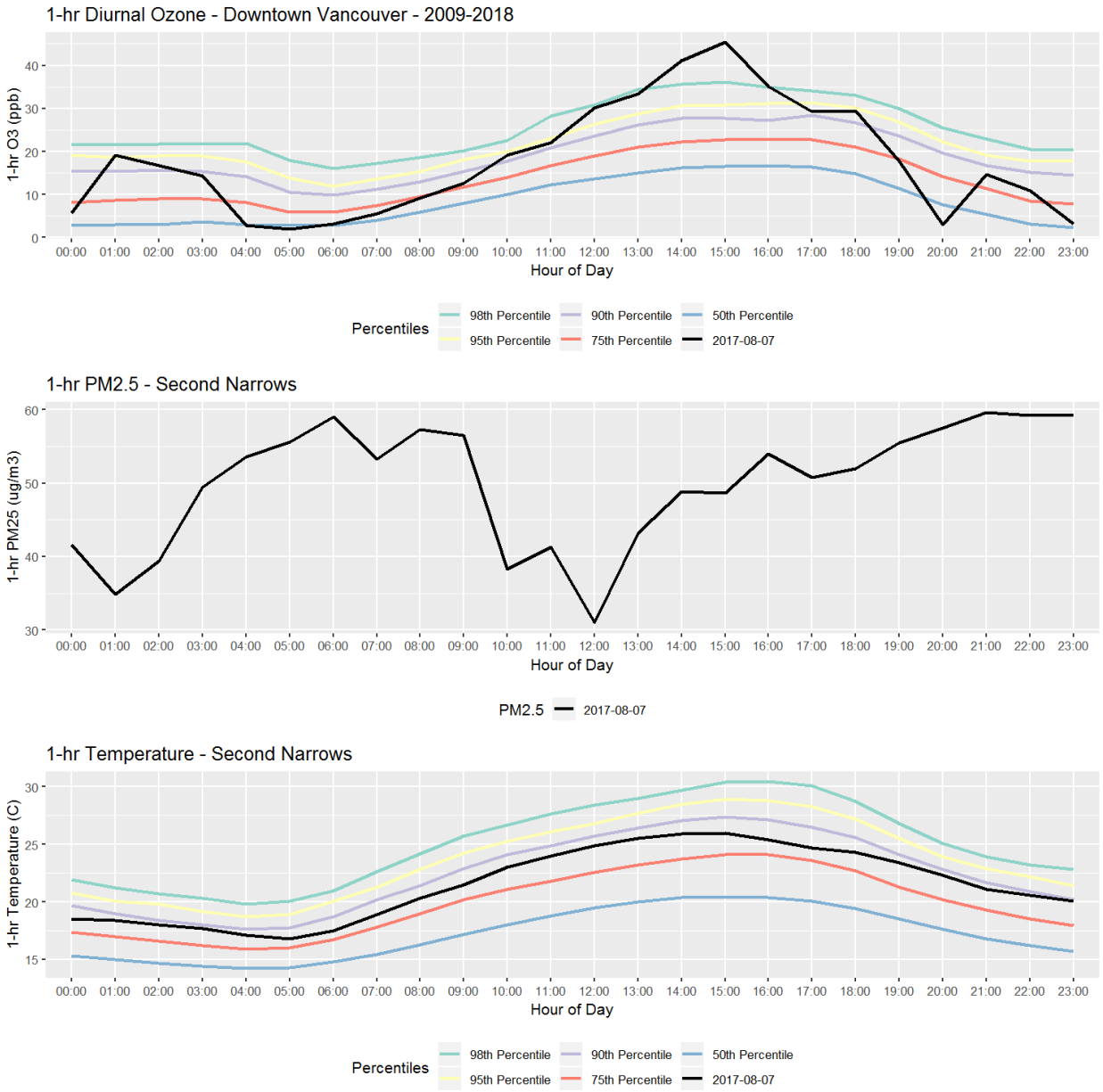


Figure III-16. Historical diurnal plots of ozone (upper) and temperature (lower) and diurnal plot of $PM_{2.5}$ concentrations (middle) recorded at the downtown Vancouver station and Second Narrows station in North Vancouver on August 7, 2017.

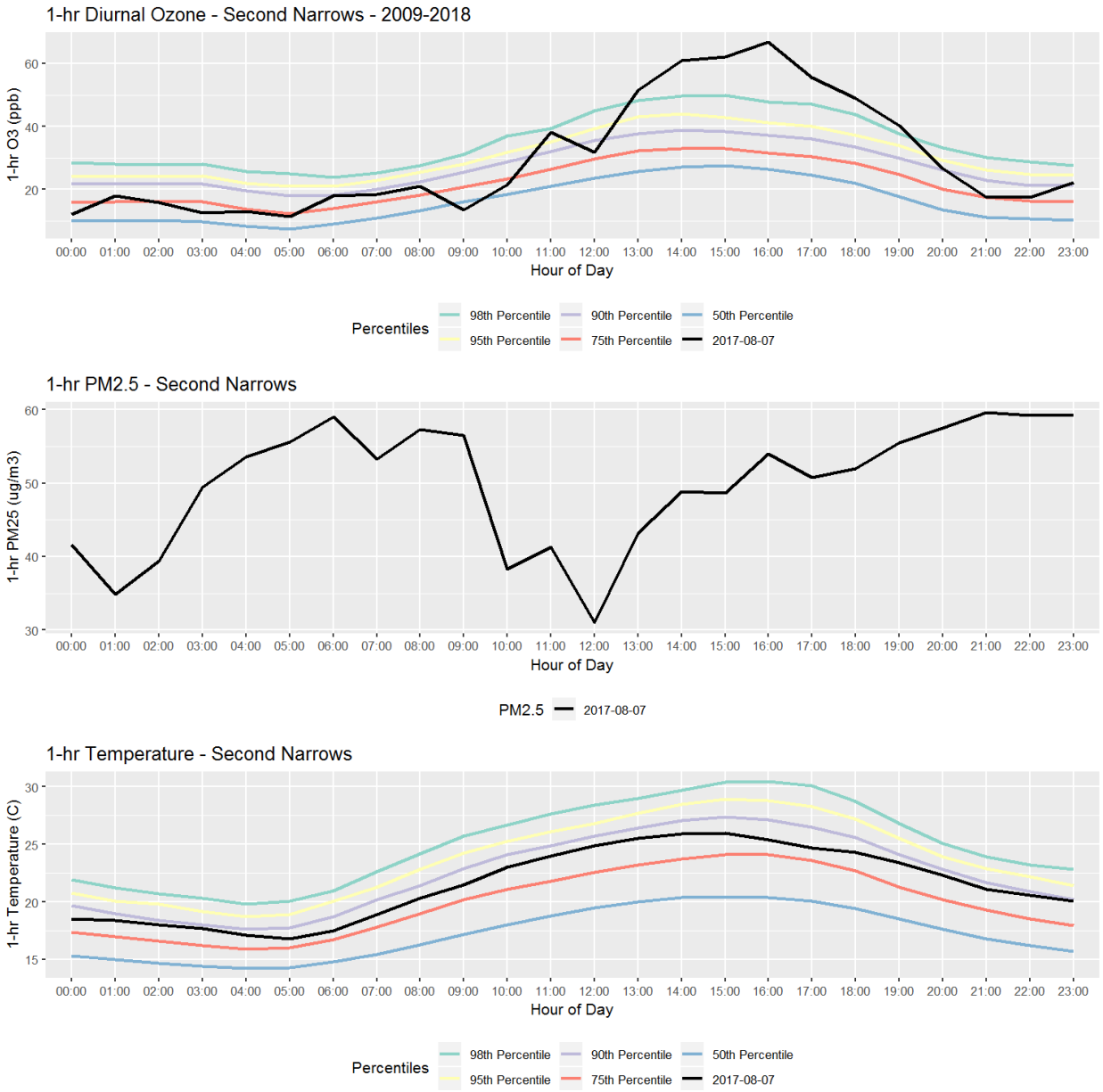


Figure III-17. Historical diurnal plots of ozone (upper) and temperature (lower) and diurnal plot of $PM_{2.5}$ concentrations (middle) recorded at Second Narrows station in North Vancouver on August 7, 2017.

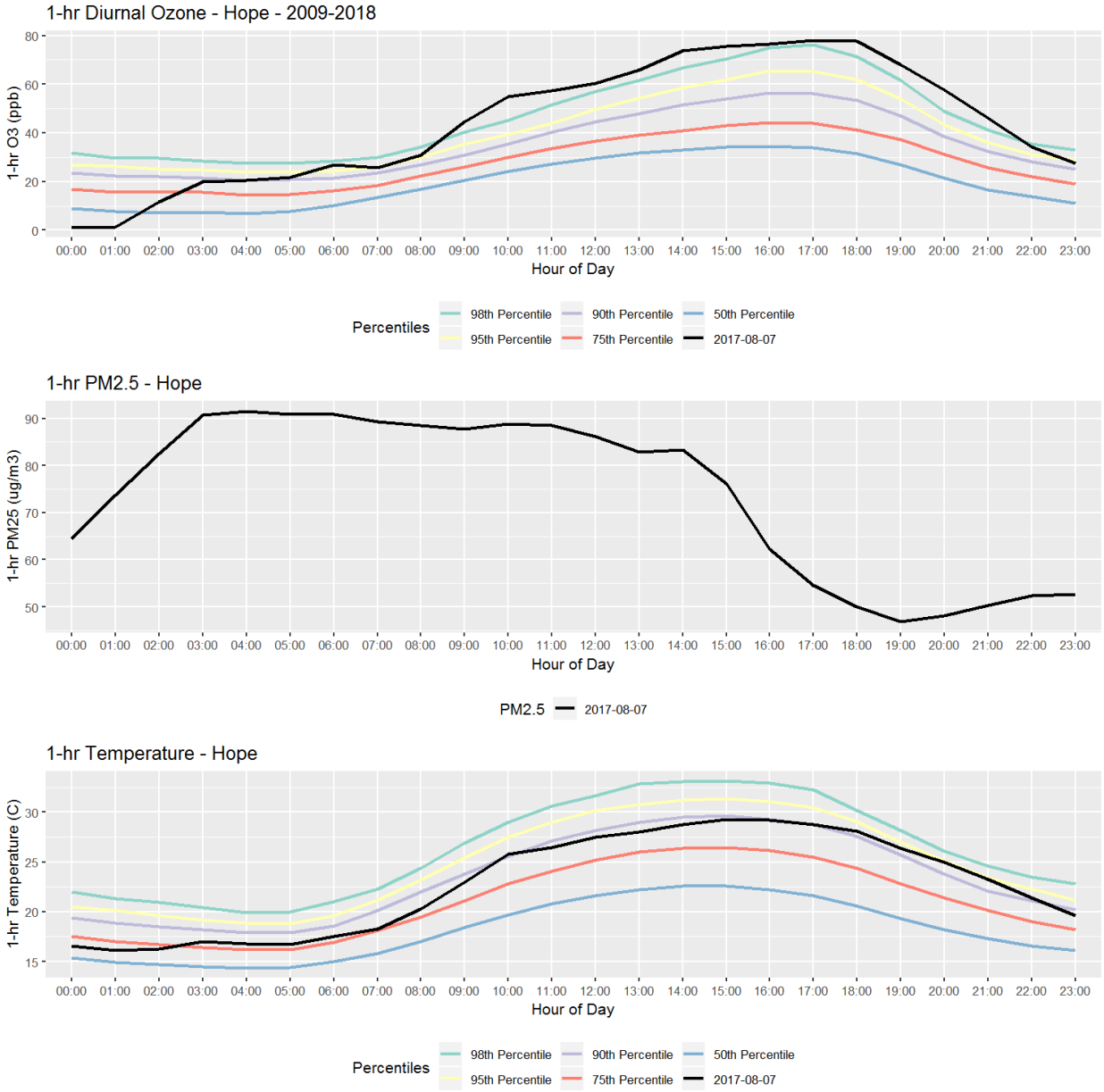


Figure III-18. Historical diurnal plots of ozone (upper) and temperature (lower) and diurnal plot of $PM_{2.5}$ concentrations (middle) recorded at Hope on August 7, 2017.

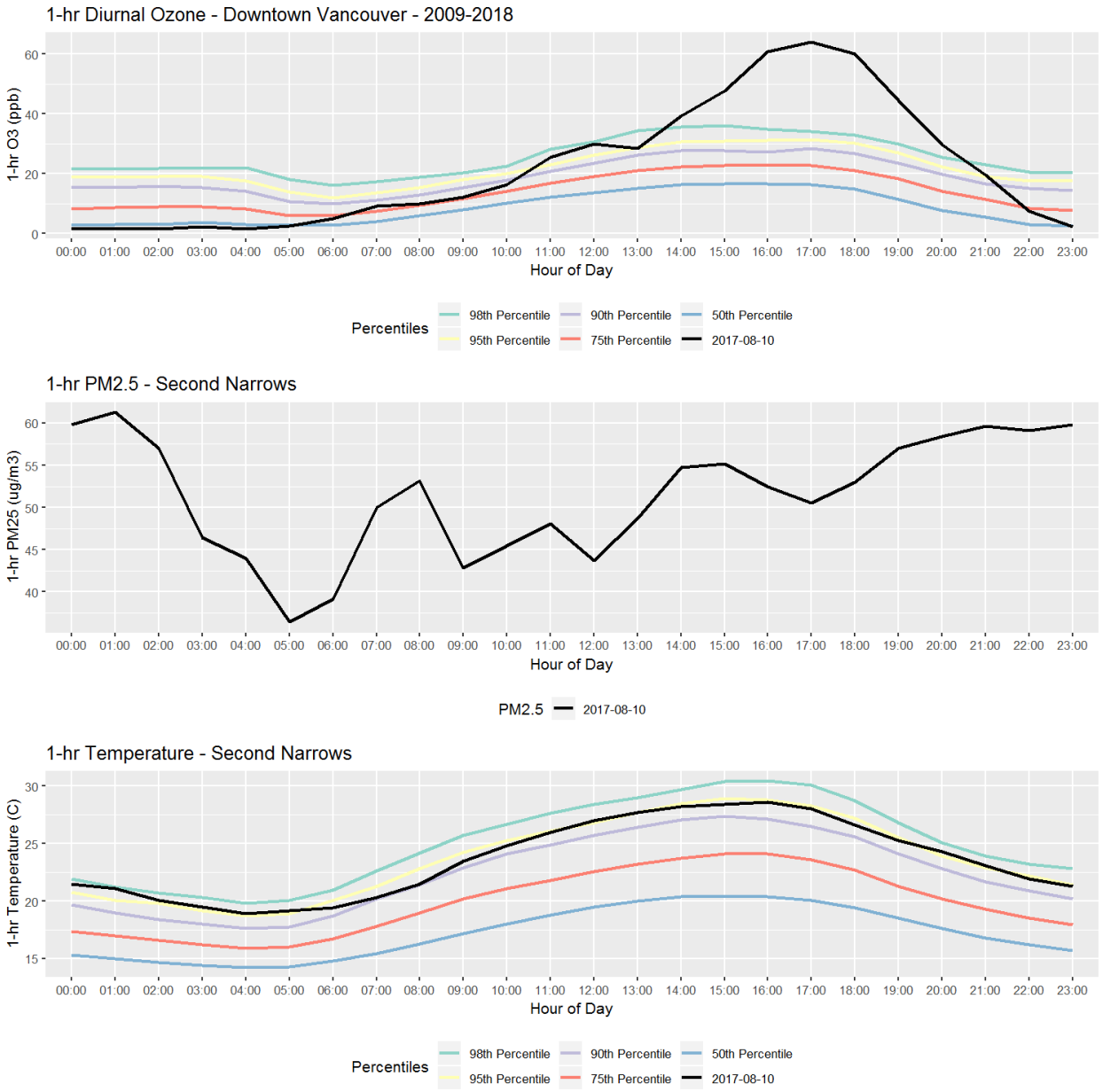


Figure III-19. Historical diurnal plots for ozone (upper) and temperature (lower) and diurnal plot of $PM_{2.5}$ concentrations (middle) recorded at the downtown Vancouver station and Second Narrows station in North Vancouver on August 10, 2017.

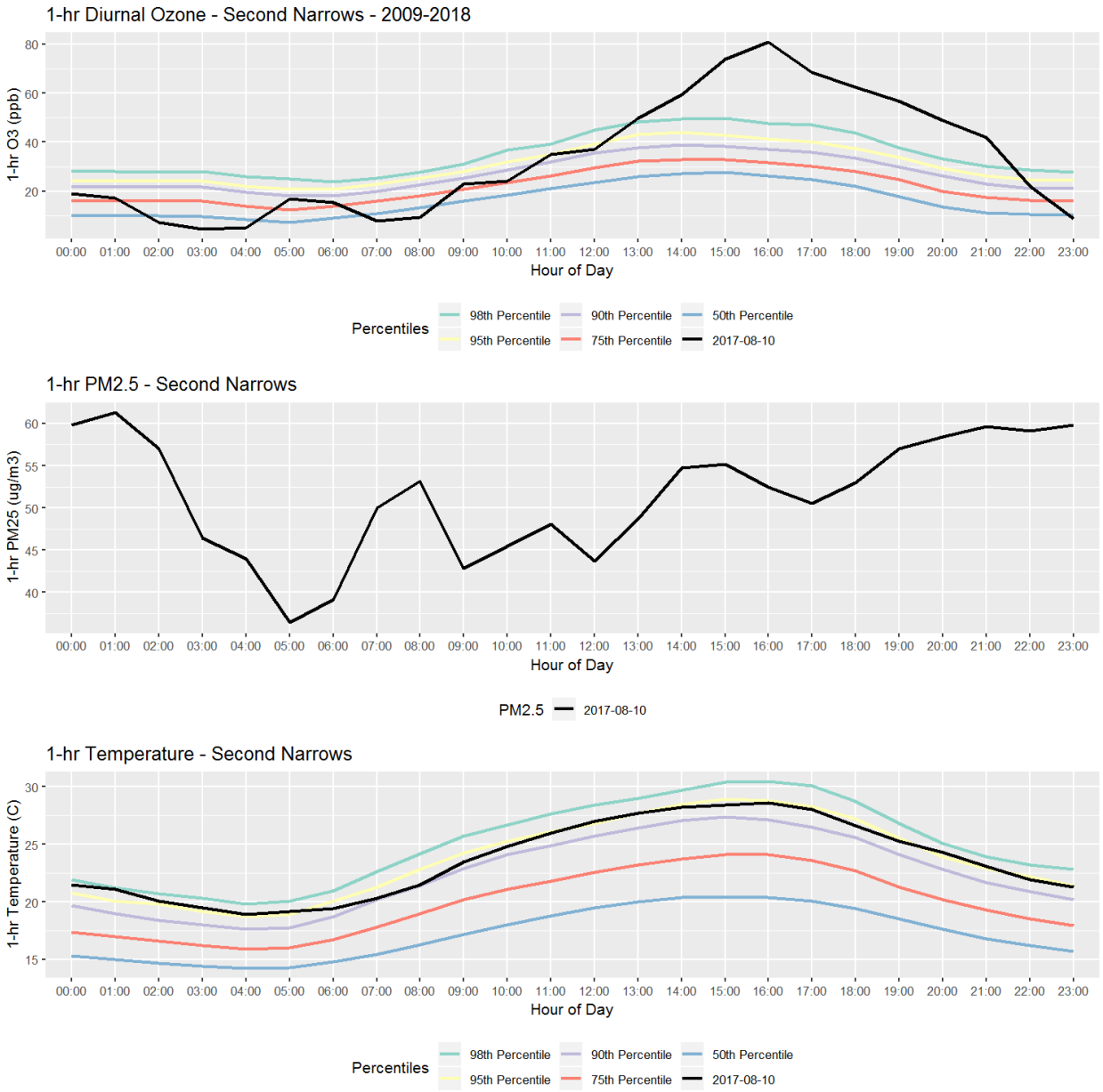


Figure III-20. Historical diurnal plots of ozone (upper) and temperature (lower) and diurnal plot of $PM_{2.5}$ concentrations (middle) recorded at Second Narrows station in North Vancouver on August 10, 2017.

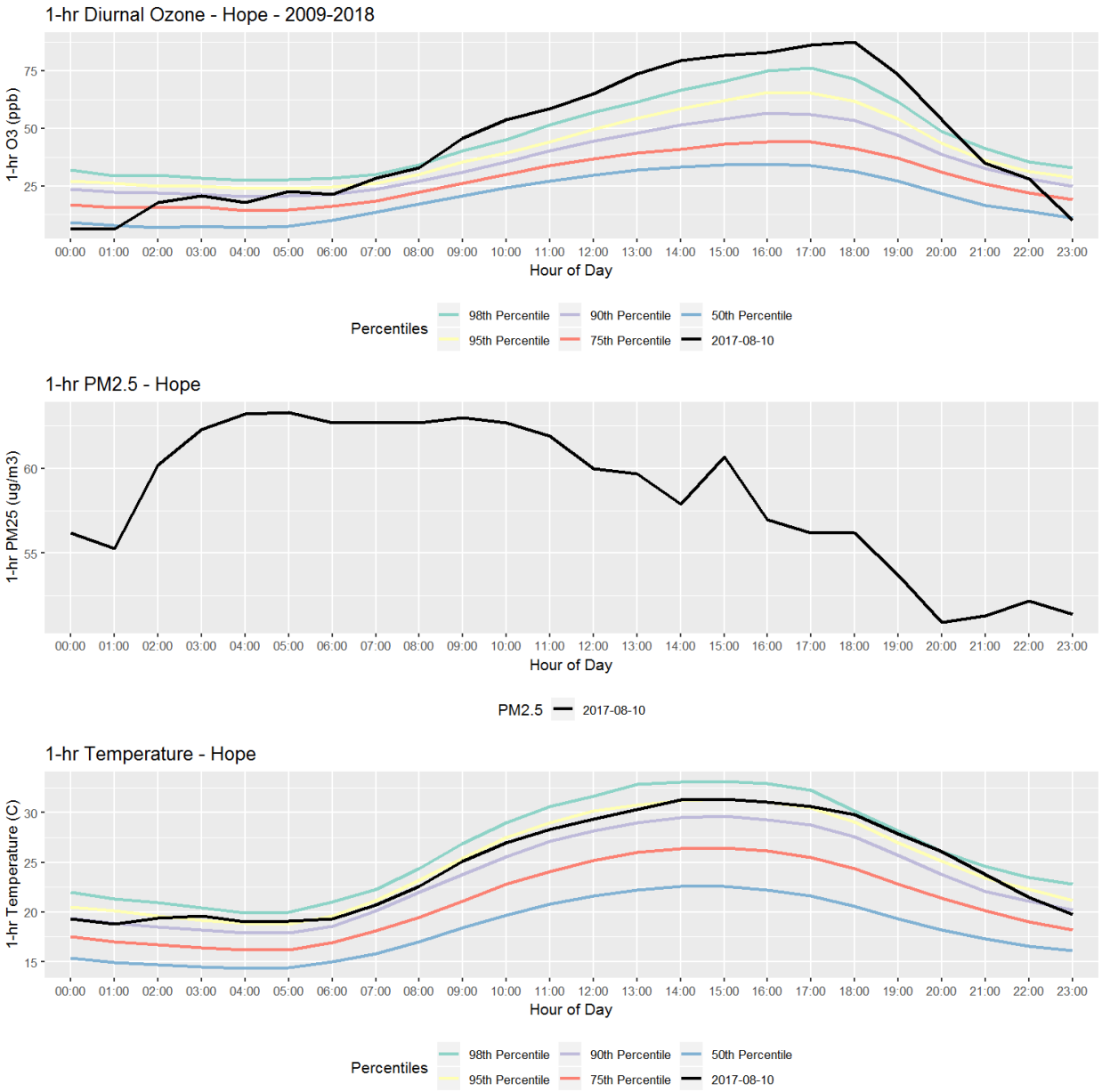


Figure III-21. Historical diurnal plots of ozone (upper) and temperature (lower) and diurnal plot of $PM_{2.5}$ concentrations (middle) recorded at Hope on August 10, 2017.

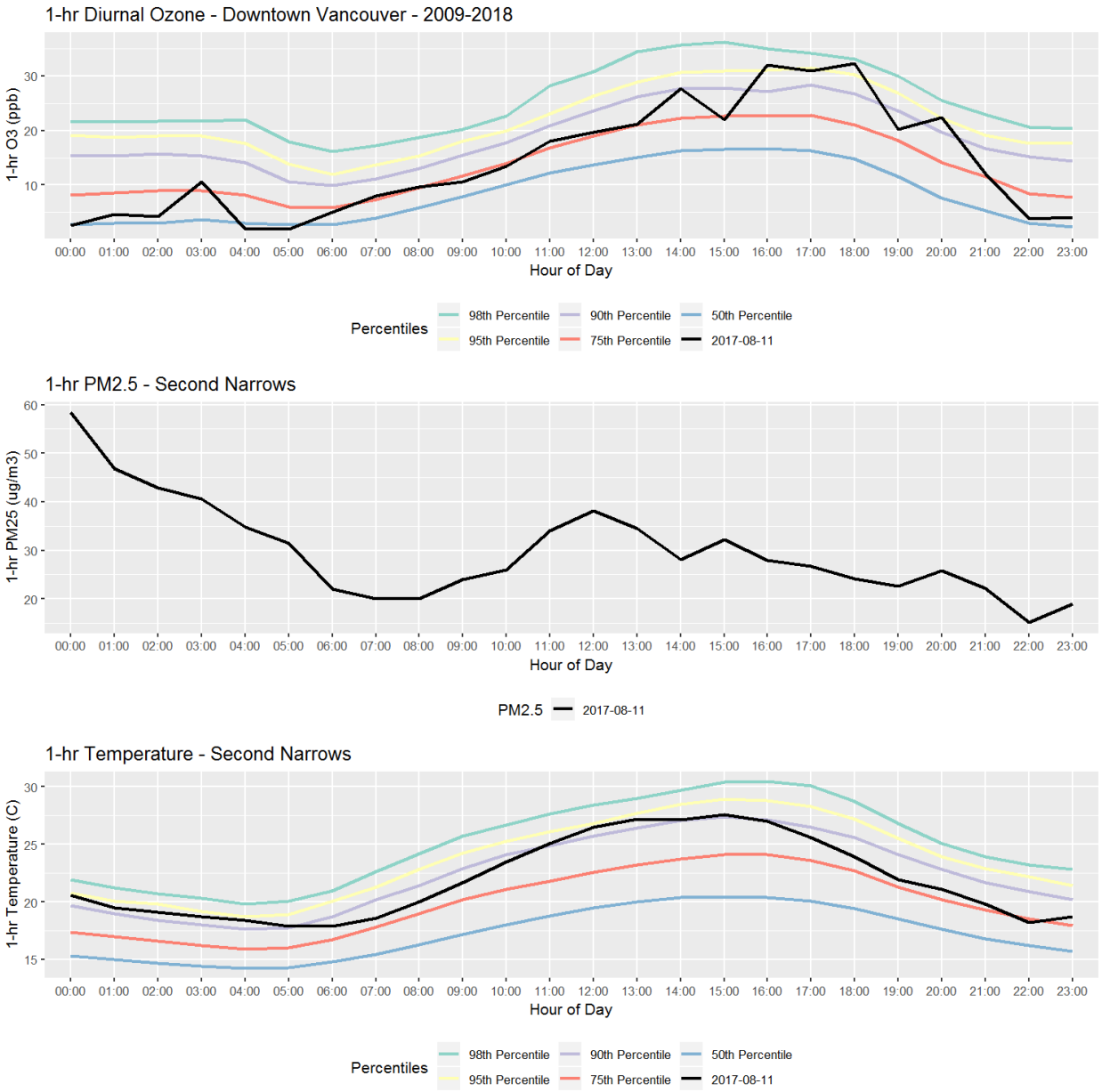


Figure III-22. Historical diurnal plots of ozone (upper) and temperature (lower) and diurnal plot of $PM_{2.5}$ concentrations (middle) recorded at the downtown Vancouver station and Second Narrows station in North Vancouver on August 11, 2017.

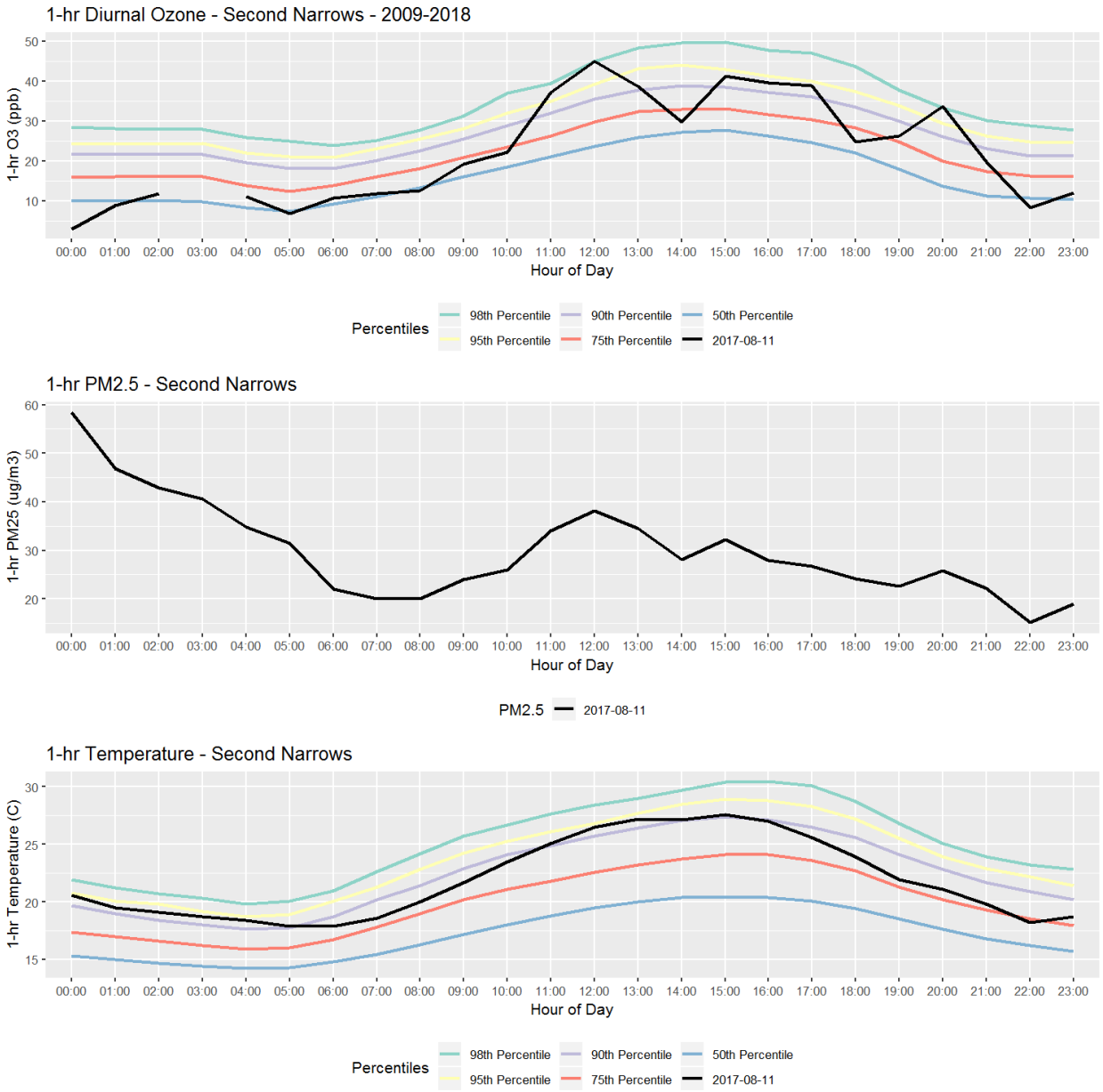


Figure III-23. Historical diurnal plots of ozone (upper) and temperature (lower) and diurnal plot of $PM_{2.5}$ concentrations (middle) recorded at Second Narrows station in North Vancouver on August 11, 2017.

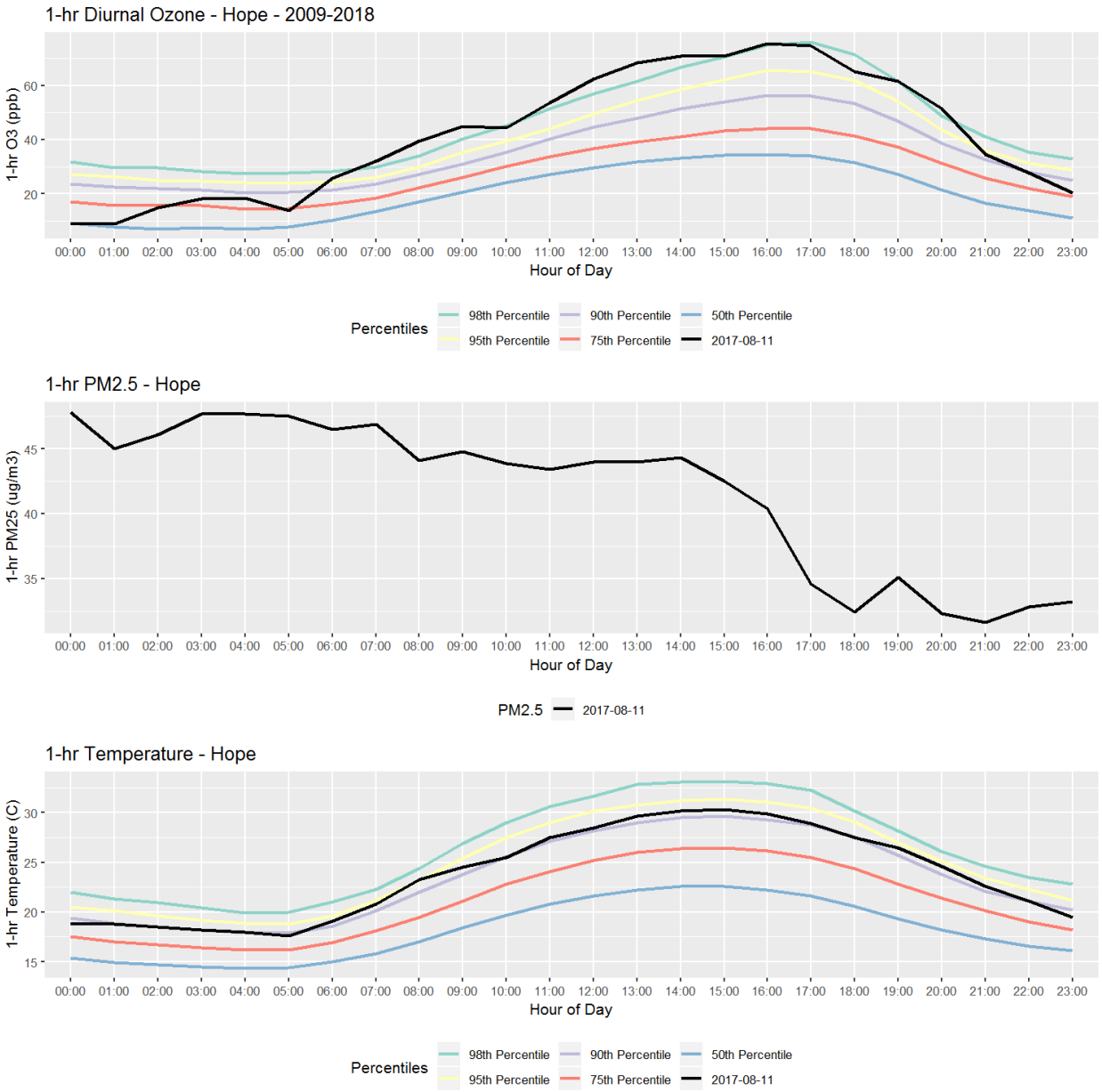


Figure III-24. Historical diurnal plots of ozone (upper) and temperature (lower) and diurnal plot of $PM_{2.5}$ concentrations (middle) recorded at Hope on August 11, 2017.