Condition of Environment – Air Indicators

Data Analysis/Visualization Methodology

Data Source

Data used in the data analysis and visualization is from Alberta's long-term air quality monitoring network, which is publicly available through the Alberta Air Data Warehouse at https://www.alberta.ca/access-air-quality-and-deposition-data.aspx.

Limitations of the Dataset

The spatial coverage of the current long-term monitoring network is concentrated in central and northeastern Alberta and the majority of stations are located in/near communities. Therefore, data is not available for all parts of the province. The types and number of monitoring stations used for each indicator are given below:

- **NO_2:** 61 monitoring stations met completeness criteria for annual average and peak NO_2 in 2021.
    - 35 Community monitoring stations, 14 Regional monitoring stations, and 12 Near Industrial Facility monitoring stations.
- **O_3:** 47 monitoring stations met completeness criteria for annual peak O_3 in 2021.
    - 32 Community monitoring stations, 12 Regional monitoring stations, and 3 Near Industrial Facility monitoring stations.
- **$PM_{2.5}$:** 50 monitoring stations met completeness criteria for annual average and peak $PM_{2.5}$ in 2021.
    - 32 Community monitoring stations, 11 Regional monitoring stations, and 7 Near Industrial Facility monitoring stations.
- **SO_2**: 65 monitoring stations met completeness criteria for annual average and peak SO_2 in 2021.
    - 31 Community monitoring stations, 16 Regional monitoring stations, 15 Near Industrial Facility monitoring stations, and 3 Local Issues monitoring stations.

Annual Average and Peak Metric Calculations

The annual average and peak metrics for the indicators were calculated for each continuous ambient air monitoring station in Alberta's long-term air monitoring network using the statistical forms shown in Table 1. The indicator metrics are the same as are used for the Canadian Ambient Air Quality Standards (CAAQS) metrics and follow the calculation methodology detailed in the Guidance Documents for each pollutant published by the Canadian Council of Ministers of Environment (CCME) (CCME, 2012; 2020a; 2020b; 2021). O_3 only has a peak metric on the O_3 indicator webpage, just as there is only a peak metric for the O_3 CAAQS.

Table 1: Statistical form for the annual average and peak metrics for each pollutant.

Metric	Parameter	Statistical Form
Annual Average	NO_2	annual average of all valid hourly data in a year
	SO_2	annual average of all valid hourly data in a year
	$PM_{2.5}$	annual average of all valid daily average values in a year
Peak	NO_2	annual 98th percentile of the daily maximum 1-hour average concentrations
	SO_2	annual 99th percentile of the daily maximum 1-hour average concentrations
	$PM_{2.5}$	annual 98th percentile of the daily 24-hour average concentrations
	O_3	annual 4th highest daily maximum 8-hour rolling average concentrations

Data completeness criteria used in the calculation of each metric:

- **NO_2:**
    - Daily maximum = at least 75% valid hours in a day, except if the daily maximum based on the available hours exceeds 60 ppb, then the daily maximum is retained in the calculation.

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- Peak value = at least 75% valid daily maximums in the year and 60% in each quarter, except if the 98th percentile based on the available daily maximums exceeds 60 ppb, then the year is included.
- Annual average = at least 75% valid hours in a year and 60% valid hours in each quarter, except if the annual average exceeds 17 ppb and at least 50% valid hours are available in each quarter.

- **SO$_2$:**
- Daily maximum = at least 75% valid hours in a day, except if the daily maximum based on the available hours exceeds 70 ppb, then the daily maximum is retained in the calculation.
- Peak value = at least 75% valid daily maximums in the year and 60% in each quarter, except if the 98th percentile based on the available daily maximums exceeds 70 ppb, then the year is included.
- Annual average = at least 75% valid hours in a year and 60% valid hours in each quarter, except if the annual average exceeds 5 ppb and at least 50% valid hours are available in each quarter.

- **PM$_{2.5}$:**
- Daily average = at least 75% valid hours in a day.
- Peak value = at least 75% valid daily averages in a year and 60% in each quarter
- Annual average = at least 75% valid daily averages in a year and 60% in each quarter.

- **O$_3$:**
- 8-hour rolling average = at least 75% of hours in 8-hour period.
- Daily maximum = at least 75% of valid 8-hour rolling averages in a day, except if the daily maximum based on the available hours exceeds 62 ppb, then the daily maximum is retained in the calculation.
- Peak value = at least 75% valid daily maximums in the combined 2nd and 3rd quarter of the year, except if the 4th highest value based on the available daily maximums exceeds 62 ppb, then the year is included.

Time Series Graphs

All Indicators

Provincial average = for each year, the annual average/peak concentration was averaged across all stations in the long-term air quality monitoring network that monitored a valid annual average/peak concentration.

10th and 90th percentiles = for each year, the 10th and 90th percentile in annual average/peak concentration across all stations in the long-term air quality monitoring network monitoring a valid metric were calculated.

Results for major population centres = The average concentration across all stations in a given large population centre (Calgary, Edmonton, Fort McMurray, Grande Prairie, Lethbridge, Medicine Hat, and Red Deer) was calculated to give one averaged concentration value for each city each year. All stations in the long-term air quality monitoring network within the municipal boundaries of the city were included in each spatial average.

For SO$_2$ Indicator only

The average concentration across each station type (Community, Near Industrial Facility, and Regional) were calculated to give one averaged concentration value for each station type each year. For more information on the monitoring station types see the "Five-year provincial air quality and deposition monitoring, evaluation and reporting (MER) plan (2021-2025)" (Aklilu, et al., 2021).

Trend Estimates

Trends in annual average/peak concentrations were estimated for each indicator using the openair package (Carslaw and Ropkins, 2012) in R (R Core Team, 2021) and TheilSen function therein. For information on this package and function, see the OpenAir user manual at https://bookdown.org/david_carslaw/openair/.

For NO$_2$, SO$_2$, and O$_3$, trend estimates for the provincial average and large population centres were calculated beginning in 2000 or the earliest date with monitoring data using the annual average/peak concentration and required at least 10 years of data.

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Trends in more recent years (2012-2021) for NO_2 and SO_2 were estimated using monthly average concentrations for each monitoring station. The 10-year trend results are provided in the maps in Figures 1a and 1b on the NO_2 and SO_2 indicator webpages and can be viewed for each station when the station's symbol is selected. Data were deseasonalized and autocorrelation was considered in the trend uncertainty estimates. A data completeness threshold of 75% was required when aggregating the data to monthly averages. Using this data completeness criteria resulted in missing data for some months. In such cases, the missing months could not exceed six months in a given year if the pattern of missing months was random and could not exceed four months in a year if they were consecutive months that were missing. The threshold to report a significant trend was a p-value <0.05.

Seasonal variation bar plots for $PM_{2.5}$ and O_3

Monthly average concentration from each station monitoring during the year(s) included in the bar plot were included. The data completeness criteria for monthly average concentration calculation was at least 50% of hourly data available in a given month. The median value of the monthly average concentrations across all stations is represented by the bar in the plot, while the maximum value across all monthly average concentrations is shown with the whisker extending from the top of each bar.

Comparison to Alberta's Ambient Air Quality Objectives

Comparison to Alberta's Ambient Air Quality Objectives (AAAQOs) followed the rounding and comparison rules stipulated in Section 3.1.2 of the "Air Monitoring Directive Chapter 9: Reporting" (Alberta Environment and Parks [AEP], 2016). For a summary of the AAAQOs in effect in Alberta and used in this assessment, see the "Alberta Ambient Air Quality Objectives and Guidelines Summary" (AEP, 2019).

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