Condition of Environment Report – Air Component

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 publically 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:** 59 monitoring stations met completeness criteria for annual average NO_2 in 2020.
  - 34 Community monitoring stations, 15 Regional monitoring stations, and 10 Near Fence (industrial source) monitoring stations.
- **O_3:** 46 monitoring stations met completeness criteria for annual peak O_3 in 2020.
  - 32 Community monitoring stations, 12 Regional monitoring stations, and 2 Near Fence (industrial source) monitoring stations.
- **$PM_{2.5}$:** 49 monitoring stations met completeness criteria for annual average $PM_{2.5}$ in 2020.
  - 32 Community monitoring stations, 11 Regional monitoring stations, and 6 Near Fence (industrial source) monitoring stations.
- **SO_2**: 64 monitoring stations met completeness criteria for annual average SO_2 in 2020.
  - 30 Community monitoring stations, 17 Regional monitoring stations, 14 Near Fence (industrial source) monitoring stations, and 3 Local Issues monitoring stations.

Annual Average and Peak Metric Calculations

The annual average and peak metrics for the CoE-Air indicators were calculated for each continuous ambient air monitoring station in Alberta as follows:

- Annual Average (NO_2 and SO_2) = annual average of all valid hourly data in a year.
- Annual Average ($PM_{2.5}$) = annual average of all valid daily average values in a year.
- Peak (O_3) = annual 4th highest daily maximum 8-hour rolling average values.

The data completeness criteria used in the calculation of each metric are:

- Annual Average (NO_2 and SO_2):
  - At least 75% valid hours in a year and 60% valid hours in each quarter.
- Annual Average ($PM_{2.5}$):
  - Daily average = at least 75% valid hours in a day.
  - Annual average = at least 75% valid daily averages in a year and 60% in each quarter.
- Peak (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 63 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 63 ppb, then the year is included.

The methods used to develop the $PM_{2.5}$ and O_3 indicators, including calculation of the metrics and data completeness criteria, are the same as are used for the Canadian Ambient Air Quality Standards metrics. These methods are detailed in the

"Guidance Document on Achievement Determination: Canadian Ambient Air Quality Standards for Fine Particulate Matter and Ozone" (2012) PDF published by the Canadian Council of Ministers of Environment (available at: https://ccme.ca/en/res/pn1483_gdad_eng-secured.pdf).

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" (2016) published by Alberta Environment and Parks (available at: https://open.alberta.ca/publications/air-monitoring-directive-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" (2019) published by Alberta Environment and Parks (available at: https://open.alberta.ca/publications/9781460134856).

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

10%ile – 90%ile = 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)" (2021) PDF published by Alberta Environment and Parks (available at: https://open.alberta.ca/publications/five-year-provincial-air-quality-deposition-mer-plan-2021-2025).

Trend Estimate

Trends in annual average/peak concentrations were estimated for each indicator using the openair package[1] in R and TheilSen function therein. For information on this package and function, see the OpenAir user manual at https://bookdown.org/david_carslaw/openair/.

Trend estimates presented in the legend of the time series graphs for NO_2, SO_2, and O_3 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. The following markers were used to indicate trend results in the legend: ○ = no significant trend detected; Δ = increasing trend; and ∇ = decreasing trend.

Trends in more recent years (2011-2020) for NO_2 and SO_2 were estimated using monthly average concentrations for each monitoring station using the openair TheilSen function. Data was deseasonalized and autocorrelation was considered in the trend uncertainty estimates. 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.

[1] **Carslaw DC, Ropkins K (2012). "openair — An R package for air quality data analysis." Environmental Modelling & Software, 27–28(0), 52–61. ISSN 1364-8152, doi: 10.1016/j.envsoft.2011.09.008.**

Box Plots for $PM_{2.5}$ and O_3

Monthly average concentration from each station monitoring at the time were used to create the boxplots for $PM_{2.5}$ and O_3. The data completeness criteria for monthly average concentration calculation was at least 50% of hourly data available in a given month. Figure 1 shows a legend for the box plots. In the box plots (also referred to as box-and-whisker plots), the box shows the first and third quartiles (the 25th and 75th percentiles, respectively), as well as the median value. The whiskers extending from the ends of the box have a maximum length of 1.5 times the interquartile range (the length of the box). If there are data points outside this range (outliers), the points are shown as solid circles and the whiskers end at the highest or lowest data points within the range of the whisker.

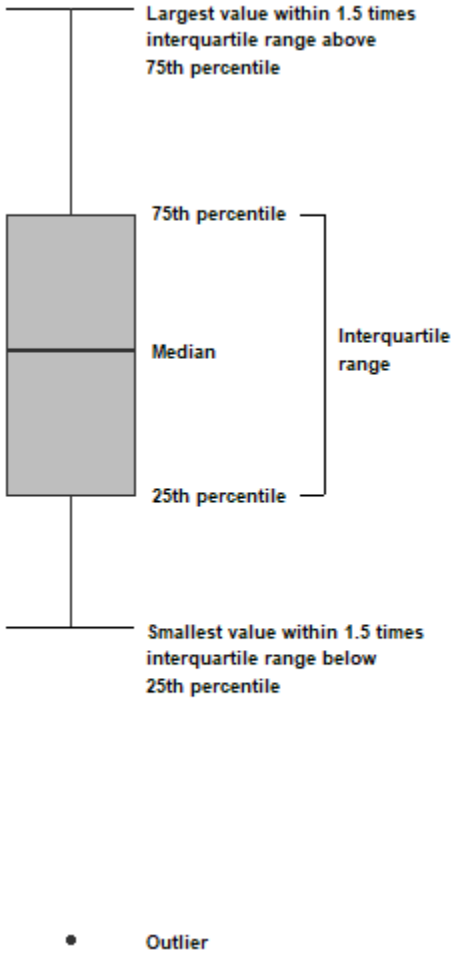

Figure 1: Legend describing box plots.