**Environmental Reporting BC**
**`rcaaqs` Enhancements – Methods for SO$_2$ and NO$_2$**

## METRIC VALUES

**SO$_2$**
(i) The 3-year average of the annual 99$^{th}$ percentile of the SO$_2$ daily maximum 1-hour average concentrations
(ii) The arithmetic average over a single calendar year of all 1-hour average SO$_2$ concentrations

**NO$_2$**
(i) The 3-year average of the annual 98$^{th}$ percentile of the NO$_2$ daily maximum 1-hour average concentrations
(ii) The arithmetic average over a single calendar year of all 1-hour average NO$_2$ concentrations

## METRIC CALCULATIONS

1. <u>3-year average of the annual 98$^{th}$/99$^{th}$ percentile of the daily maximum 1-hour average concentrations</u>

1.1 Calculating the Daily 1-hour Maximum Concentration
The daily 1-hour maximum concentration refers to the maximum 1-hour value reported over a 24-hour period (midnight to midnight, local standard time). The value is to be reported to the nearest 0.1 ppb.

1.2 Calculating the Annual 98$^{th}$ or 99$^{th}$ Percentile Value
The 98$^{th}$ percentile is the daily value out of a year of monitoring data for which 98 percent of all values are less than or equal to this level, and 2% are over. The 99$^{th}$ percentile is the daily value out of a year of monitoring data for which 99 percent of all values are less than or equal to this level, and 1% are over. Annual 98$^{th}$ and 99$^{th}$ percentiles are to be reported to the nearest 0.1 ppb.

The annual 98$^{th}$ percentile (98P) is determined and defined as follows:
- Sort all the daily 1-hour maximum concentration values for the given year into an array of numbers ordered from highest to lowest
- Repeat equal values as many times as they occur.
- Calculate the number "id" defined as,
  id = 0.98*n (the product of 0.98 and n), where
  i = the integer part of the number
  d = the decimal part of the number
  n = total number of the daily 24-hour concentration values
- The annual 98P is then defined to be the (n-i)$^{th}$ largest value.
- Data are reported to the nearest 0.1 ppb.

A similar procedure is used for the calculation of the 99$^{th}$ percentile, substituting id=0.99*n.

The table below describes the rank of the 98$^{th}$ and 99$^{th}$ percentile values for a given number of days.

Rank equivalent to 98th and 99th percentile values over range of valid days of reporting (data sorted in descending order).

| No. Valid Days | Rank Equivalent to Annual 98th Percentile ($NO_2$) | Rank Equivalent to Annual 99th Percentile ($SO_2$) |
|---|---|---|
| 0-50 | 1 | 1 |
| 51-100 | 2 | 1 |
| 101-150 | 3 | 2 |
| 151-200 | 4 | 2 |
| 201-250 | 5 | 3 |
| 251-300 | 6 | 3 |
| 301-350 | 7 | 4 |
| 351-366 | 8 | 4 |

**\*\* Note:** A similar procedure has been developed for $PM_{2.5}$ in the `rcaaqs` package (`pm_98_percentile` and `quantile2` functions) and should be a good starting point.

1.3 Calculating the 3-year Average Annual 98th or 99th Percentile Value
The Annual 98th or 99th Percentile Value is repeated for each year of a 3-year period and averaged (e.g. $99P_1 + 99P_2 + 99P_3/3$). The 3-year average annual 98th or 99th percentile values are reported to the nearest integer.

2. Annual average over a single calendar year of all 1-hour average concentrations
An annual average value reflects the average of all hourly values. The annual average concentrations should be reported to the nearest 0.1 ppb.

Intermediate calculations should retain all available digits and decimal places.


**DATA COMPLETENESS CRITERIA**

1. Data completeness criteria for the 3-year average of the annual 98th/99th percentile of the daily maximum 1-hour average concentrations

1.1. For the purpose of determining a daily 1-hour maximum concentration, a valid daily value is calculated where at least 18 hourly measurements are available in a day.

1.2. For the purpose of determining an annual 98th/99th percentile an annual data set should be considered complete if there are available at least 75% of all daily-maximum 1-hour measurements AND at least 60% of all daily-maximum 1-hour measurements in each calendar quarter (Q1 Jan-Mar, Q2 Apr-Jun, Q3 Jul-Sept, Q4 Oct-Dec).

1.3 For the purpose of determining a 3-year average of the annual 98th/99th percentile of the daily maximum 1-hour average concentrations, 2 of the 3 years must be available.

**\*\* Note:** some of the above functionality is already implemented in `rcaaqs` for $PM_{2.5}$, $SO_2$, and $NO_2$, and should be a good starting point for the above.

2. Data completeness criteria for the <u>annual average over a single calendar year of all 1-hour average concentrations</u>

2.1. An annual data set should be considered complete if there are available at least 75% of all hourly measurements in a year AND at least 60% of all hourly measurements in each calendar quarter (Q1 Jan-Mar, Q2 Apr-Jun, Q3 Jul-Sept, Q4 Oct-Dec).

**EXCEPTIONS TO THE DATA COMPLETENESS CRITERIA (FOR SO$_2$ ONLY)**

**For evaluating exceptions, use the SO$_2$ CAAQS values defined here (Table 2, 2020 standard): http://www.ccme.ca/en/resources/air/air/sulphur-dioxide.html**

1. Exceptions to Data Completeness Criteria for <u>3-year average of the annual 98$^{th}$/99$^{th}$ percentile of the daily maximum 1-hour average concentrations:</u>

1.1 The daily maximum 1-hour SO$_2$ based on the available 1-hour average concentrations will be considered valid if it is greater than the 1-hour standard.

1.2 The annual 99$^{th}$ percentile based on the available daily-maximum 1-hour concentrations will be considered valid if it is greater than the 1-hour standard.

2. Exceptions to Data Completeness Criteria for the <u>annual average over a single calendar year of all 1-hour average concentrations</u>

2.1 The annual average based on the available 1-hour concentrations will be considered valid if it is greater than the annual standard.