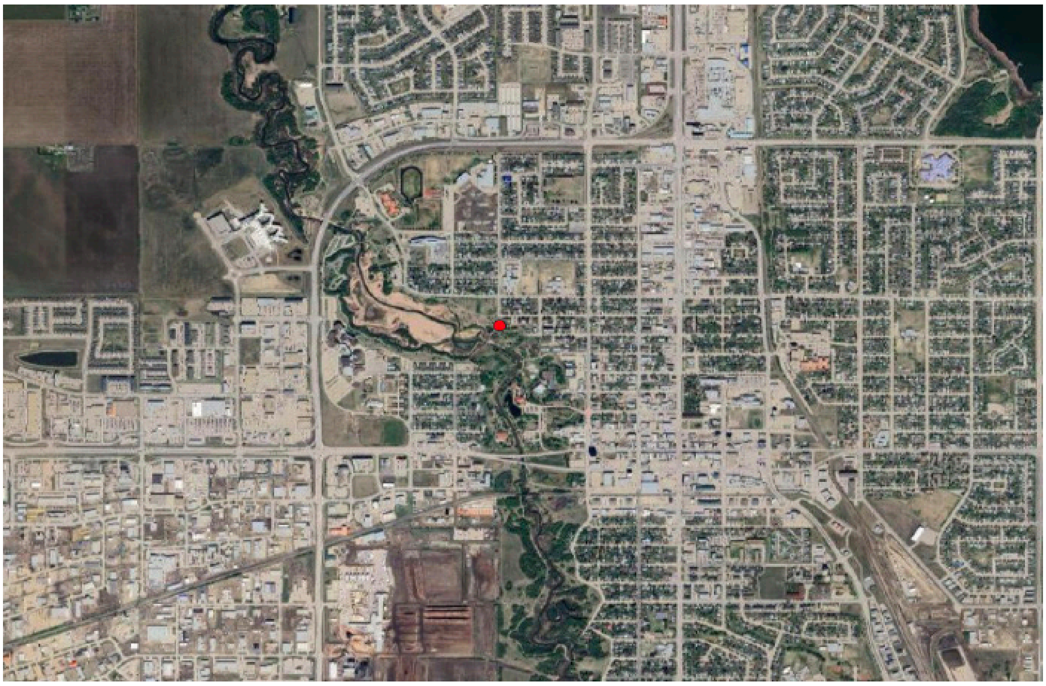
Dust Sentry Co-location Evaluation Alberta, Canada



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Introduction

Aeroqual worked with C.D. Nova Instruments Ltd, Sherwood Park, Alberta and the Peace Airshed Zone Association (PAZA) to deploy a Dust Sentry at the Henry Pirker monitoring station in Grande Prairie, a city north-west of Edmonton, Alberta. The site is equipped with a Teledyne T640x instrument which is an US EPA designated method for $PM_{2.5}$ and PM_{10}.

The purpose of the deployment was to test the performance of the Aeroqual Dust Sentry across an entire year and the impact of the Winterization Kit (Figure 1) during the winter months. The Winterization Kit includes an insulating jacket and an internal heater module that is designed to extend the lower operating temperature of the Dust Sentry to -40°C.

The Dust Sentry contained a PCX particle sensor, an optical particle counter based technology that uses a proprietary algorithm to convert particle count and size information into particulate mass (PM) measurements. The PCX particle sensor outputs values for $PM_{2.5}$ and PM_{10} as well as PM_1, PM_4 and TSP.

Figure 1: The Dust Sentry deployed at the Henry Pirker station, showing the winterization jacket.

This report summarises the $PM_{2.5}$ and PM_{10} Dust Sentry data for a 12-month period from August 2024. The Dust Sentry performance was evaluated using the metrics defined in ASTM D8406 and ASTM D8559.

Methods

The Dust Sentry was calibrated in the Aeroqual Factory using ISO 12301-1 Arizona Test Dust A1 fine as the calibration aerosol and a Palas Fidas 200 as the reference standard.

The Dust Sentry was deployed by C.D. Nova at the Henry Pirker monitoring station (Figure 2) in Grande Prairie. No further calibration was applied.

Hourly T640x, temperature and wind data from the Henry Pirker station were obtained from the PAZA continuous data viewer (http://72.13.188.77/js_PAZA.html). The T640x data includes a correction to address the previously observed positive bias in the T640x. See (https://www.regulations.gov/document/EPA-HQ-OAR-2023-0642-0031).

Figure 2: Satellite image showing the location of the Henry Pirker monitoring station in Grande Prairie, Canada (red dot).

Results

Meteorological Data

Temperatures during the field evaluation test varied from -37 to 33°C (Figure 3), offering an opportunity to test the performance of the Dust Sentry across a broad range of conditions.

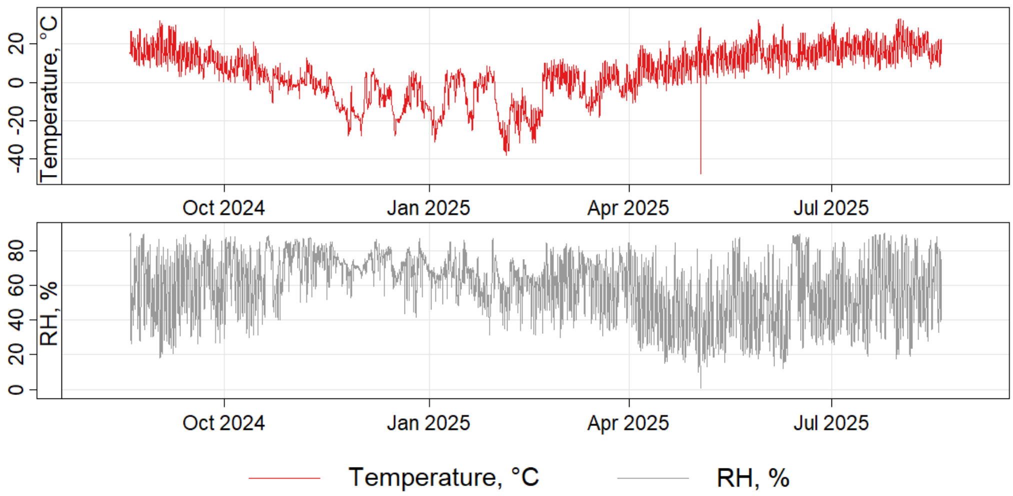

Figure 3: Hourly temperature and relative humidity measured at the Henry Pirker site.

$PM_{2.5}$ and PM_{10} Comparative Data

The time series plots for 1-hour averaged T640x and the Dust Sentry $PM_{2.5}$ and PM_{10} data are shown in Figure 4 and Figure 5, respectively. Both the T640x and Dust Sentry show episodes of elevated (up to 300 and 400 µg/m^3, respectively) $PM_{2.5}$ and PM_{10} concentrations in August and early September 2024 as well as June 2025. Table 2 shows a summary of performance metrics for 24-hour averaged Dust Sentry $PM_{2.5}$ and PM_{10} against the co-located T640x across different seasons. The Dust Sentry shows excellent agreement with the T640x data throughout the monitoring period.

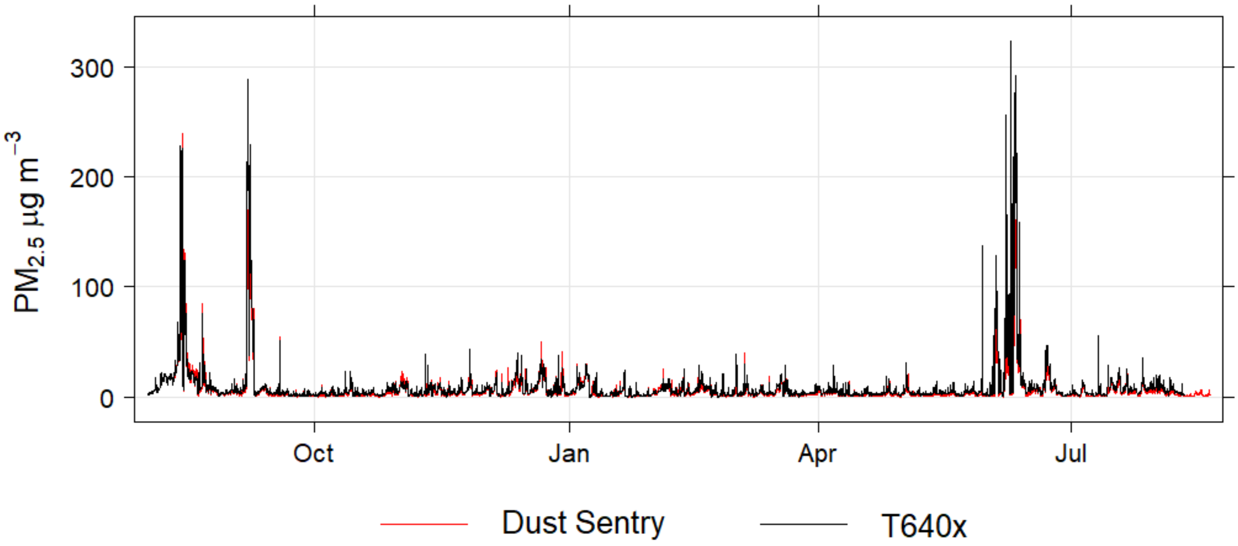

Figure 4: Hourly $PM_{2.5}$ time series data for the Dust Sentry and the co-located T640x Reference instrument.

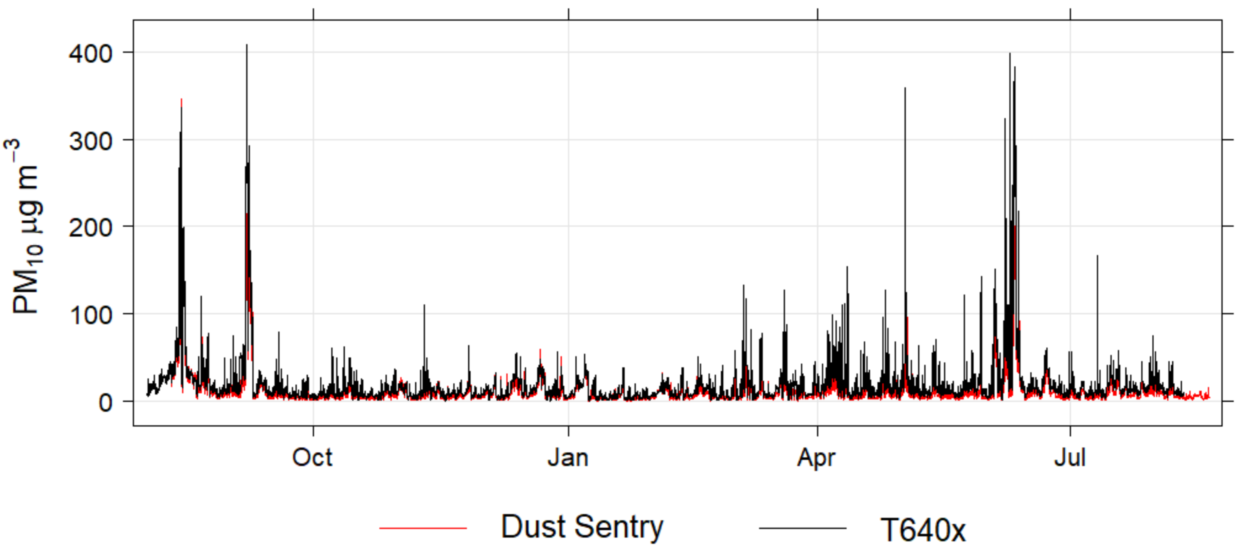

Figure 5: Hourly PM_{10} time series data for the Dust Sentry and the co-located T640x Reference instrument.

Table 1: Summary of performance metrics for 24-hour averaged Dust Sentry $PM_{2.5}$ and PM_{10} against the co-located T640x across different seasons. Metrics include coefficient of determination (R^2), mean absolute error (MAE), Root Mean Squared Error (RMSE), and observed pollution range (minimum–maximum). Seasons are defined meteorologically for the Northern Hemisphere.

Season	Mass Fraction	R^2	MAE µg/m³	RMSE µg/m³	Reference Range µg/m³
Autumn	$PM_{2.5}$	0.98	2.2	6.3	1.2 – 162.9
Spring	$PM_{2.5}$	0.83	1.4	1.8	1.7 – 18.9
Summer	$PM_{2.5}$	0.90	4.7	10.7	1.3 – 147.5
Winter	$PM_{2.5}$	0.94	1.3	1.7	0.9 – 24.1
Autumn	PM_{10}	0.98	6.2	11.2	4.2 – 217.2
Spring	PM_{10}	0.93	8.9	10.7	5.0 – 80.9
Summer	PM_{10}	0.93	9.6	15.3	5.6 – 193.0
Winter	PM_{10}	0.95	3.6	4.1	3.0 – 34.4

ASTM D8406 and D8559 Analysis

Performance metrics for the Dust Sentry were calculated following the method outlined in ASTM D8406. $PM_{2.5}$ and PM_{10} were calibrated using data from the 23 – 30 November, and the test was performed from December to January. The results show that the Dust Sentry with PCX meets the Class 1 field performance criteria for $PM_{2.5}$ and PM_{10} according to ASTM D8559 (Table 2, Figure 6). This demonstrates it achieved near-reference performance under the test conditions.

Metric	$PM_{2.5}$	PM_{10}	D8559 Class 1 Criteria
Data capture	100"%	100"%	>90%
Slope	1.03	1.06	0.9 to 1.1
Intercept	-0.21	-0.35	<5 µg/m³
R2	0.94	0.96	>0.9
MAE	0.99 µg/m³	1.30 µg/m³	<5 µg/m³
RMSE	1.60 µg/m³	1.96 µg/m³	<6 µg/m³

Table 2: Performance metrics calculated for Dust Sentry $PM_{2.5}$ and PM_{10}, based on ASTM D8406. The metrics were calculated across a period for 6 weeks using 24-hour averaged and field calibrated data.

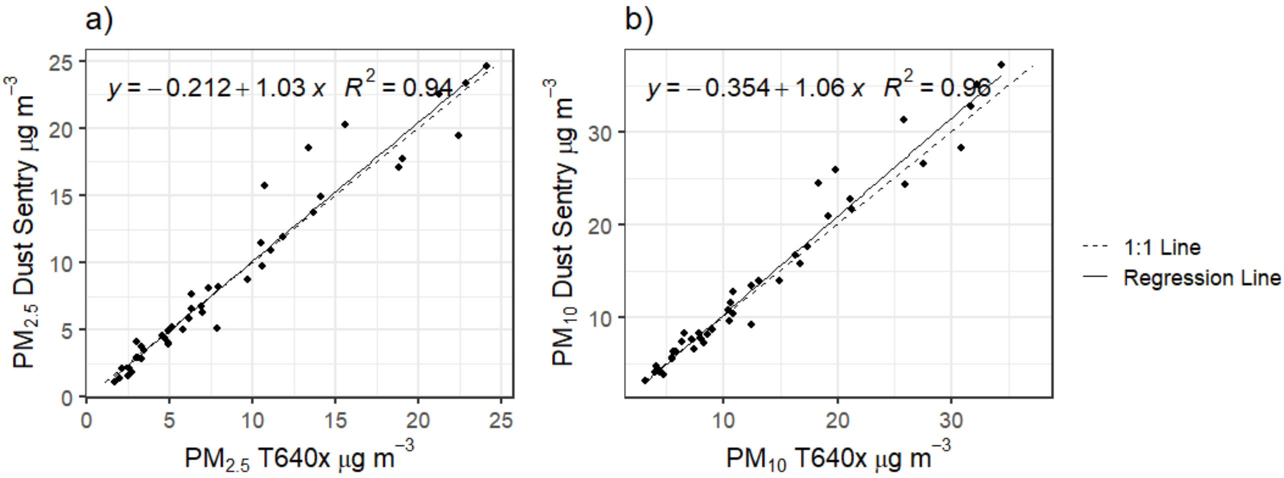

Figure 6: Scatterplots showing the calibrated $PM_{2.5}$ and PM_{10} for the ASTM test period.

Impact of Aerosol Composition

While the Dust Sentry and T640x show good agreement under most conditions, some differences are observed when $PM_{2.5}$ concentrations are elevated (>70 µg/m³), Figure 7. These days are characterised by the presence of wildfire smoke. Under these conditions, the differences between the instruments are increased.

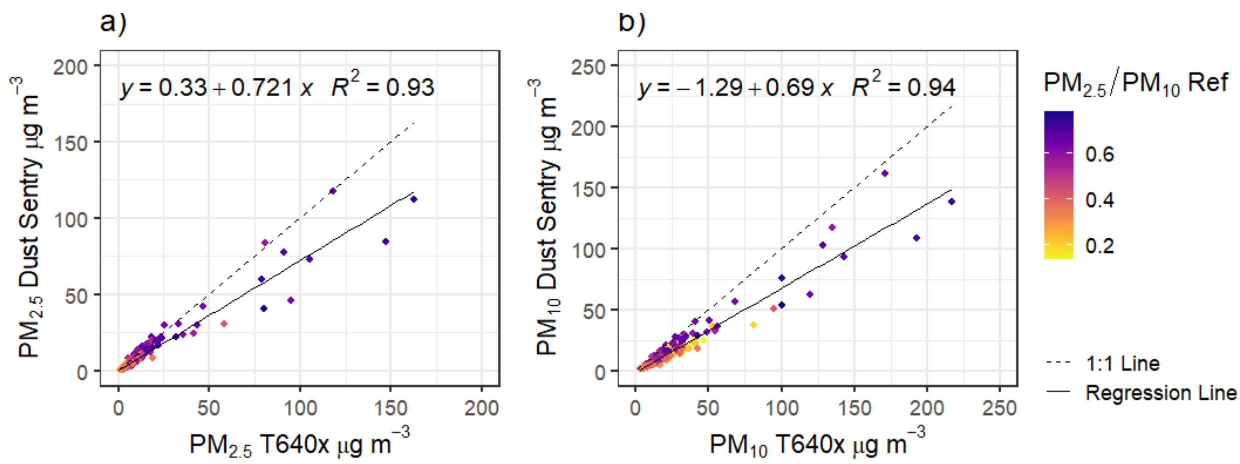

Figure 7: Scatterplot showing daily averaged $PM_{2.5}$ (a) and PM_{10} (b) against the T640x data coloured by the reference $PM_{2.5}/PM_{10}$ ratio for the whole field evaluation period.

Impact of the Winterization Kit

The hourly ambient temperature measurements from the reference site and the Dust Sentry internal temperature, with and without the winterization kit are shown in Figure 9. The Winterization Kit (installed on December 4th), maintains the temperature inside the Dust Sentry above 15°C even when the outside temperature is close to -40°C.

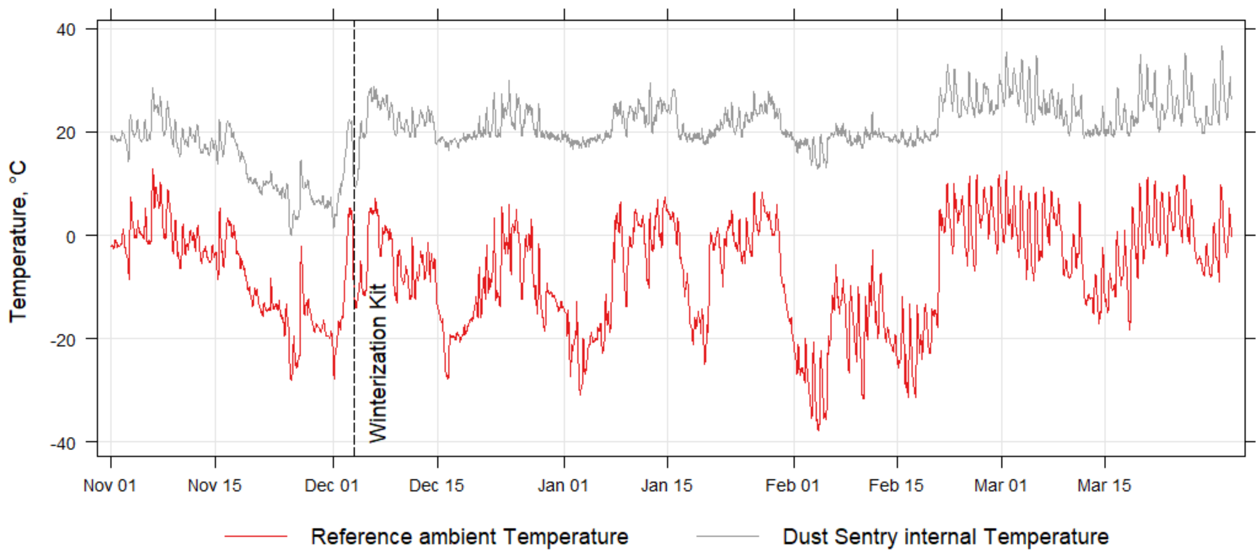

Figure 9: Hourly ambient temperature data measured at the Reference site and the Dust Sentry internal Temperature. The Winterization Kit was installed on 4th December.

The correlation between the Dust Sentry and T640x for $PM_{2.5}$ and PM_{10} (Figure 10) during the winter months (December – February) is still strong even as ambient temperatures drop to -40°C.

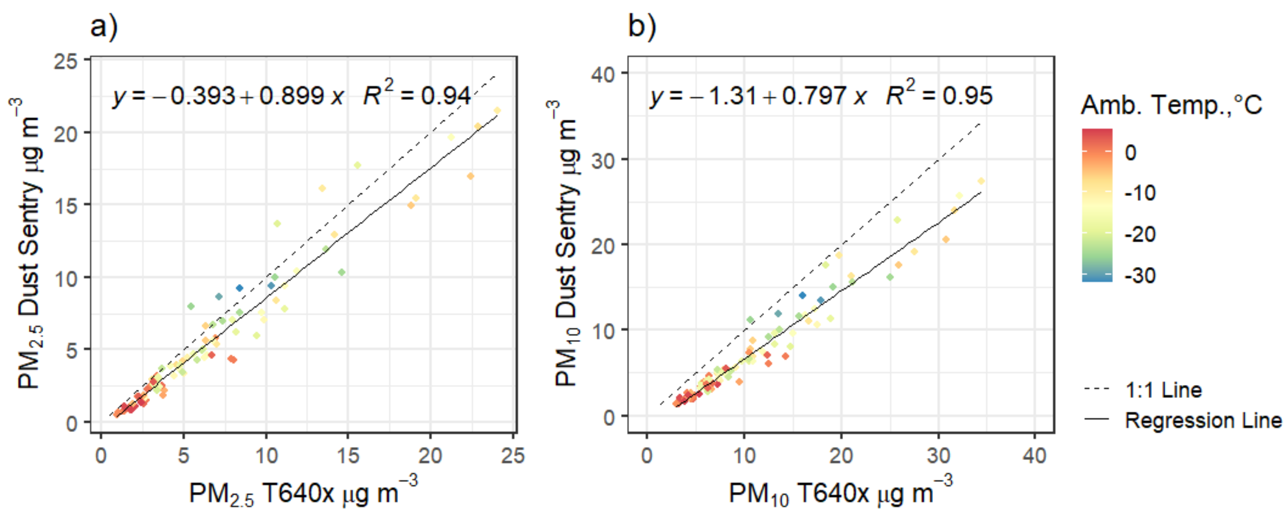

Figure 10: Scatterplot showing daily averaged $PM_{2.5}$ (a) and PM_{10} (b) against the T640x data from December - February for $PM_{2.5}$ and PM_{10}, respectively. Points are coloured by the ambient reference temperature.

Conclusion

The Dust Sentry with PCX deployed in Grande Prairie, Canada for a period of 12 months from August 2024 performed reliably throughout the monitoring period with 100% data capture and showed excellent agreement with the co-located T640x reference data.

The Winterization Kit successfully mitigated the extreme cold (-40°C) temperatures of the Canadian winter and enabled the Dust Sentry to provide reliable data throughout the winter.

Deviations between the two instruments were observed when the aerosol was dominated by fine particles ($PM_{2.5}$) emitted during wildfire events. Identification of the cause of the deviations requires further study.

References

ASTM D8406 Standard Practice for Performance Evaluation of Ambient Outdoor Air Quality Sensors and Sensor-based Instruments for Portable and Fixed-point Measurement.

ASTM D8559 Standard Specification for Ambient Outdoor Air Quality Sensors and Sensor-Based Instruments for Portable and Fixed-Point Measurement.