Field Evaluation of Low-Cost Sensors in Urban Environments

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CONTEXT

Smoke-related air pollution from wood heaters and bushfires is associated with adverse health effects including asthma exacerbations. Low-cost sensors (LCS) can help provide highly spatially resolved air quality data to supplement data from regulatory stations. However, quality assurance of LCS is important to ensure the accuracy of the data collected.

AIMS

To evaluate the performance characteristics of PurpleAir-II (PA-II) LCS, in comparison to reference or quality instruments, including a Beta attenuation mass monitor (BAM), TSI DustTrak DRX 8533, and Teledyne API T640X.

METHODS

Sensors and Study Sites: Four PA-II sensors were collocated with BAM and T640x instruments at Lidcombe, Sydney (urban site) for 10 days, and one PA-II was collocated with a DustTrak at Lyneham, Canberra, ACT (residential site) for 60 days. Both sites were periodically impacted by wood smoke, with the Lidcombe site additionally affected by urban pollution sources, including traffic.

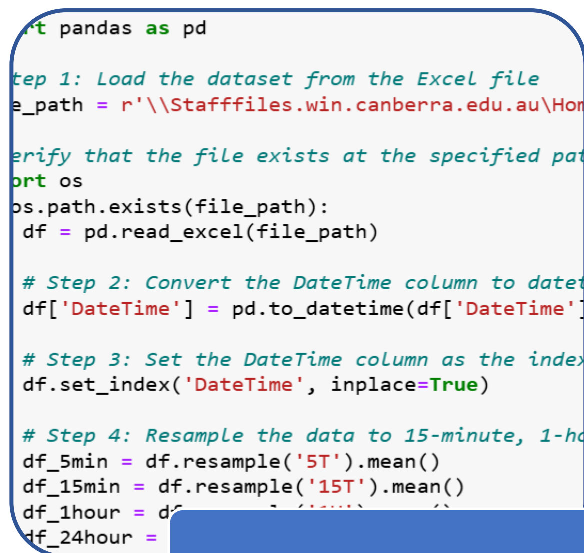
Data Collection: PA-II data were extracted using Python, and the two PA-II channels (Channel A and B) were averaged. Data were filtered to remove negative values and outliers. PA-II, BAM, T640x, and DustTrak measurements were aggregated to 5-min, 15-min, 1-hour, and 24-hour intervals with matched timestamps.

Statistical Analysis: PA-II precision was assessed using Pearson's Correlation Coefficient, with performance evaluated through linear regression and correlation against reference instruments. Data accuracy was further analysed using relative bias, MAE, RMSE, and NRMSE for each hourly dataset.

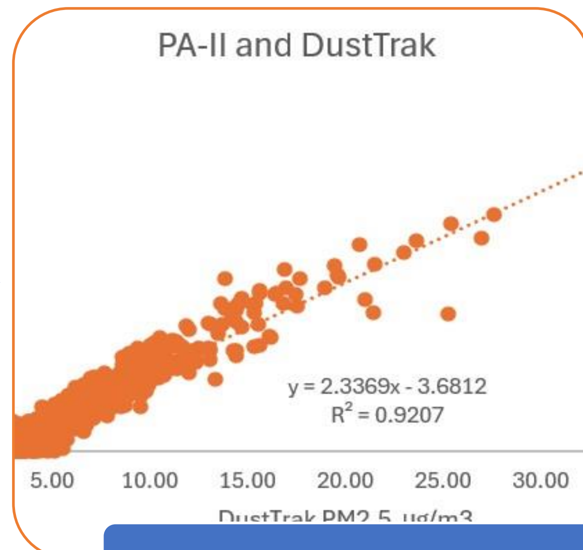
Steps for collocating and processing data for low-cost sensors

PurpleAir-II

Sensor placement



Data processing (Python)



Correlation plot

RESULTS

Intercomparison of collocated PA-II units allowed suitability for spatial variability measurements. The PA-II showed high inter-correlations **(r = 0.99)** and good accuracy (MAE < 1 µg/m³) for $PM_{2.5}$ measurements. The PA-II showed very high correlations with **DustTrak** and **T640x**, however, correlations with **BAM** were only moderate, **R^2 ~ 0.9, 0.8, and 0.66** respectively. In addition, increasing the temporal aggregation (i.e., from 2 min to 24-hour intervals) resulted in improvements in the associations between the DustTrak and T640x and the PA-II sensors, no improvements were seen with the BAM. The higher correlation with DustTrak and T640x is due to the use of the similar technology (light scattering) for PM2.5 measurement.

OUTCOME

The PA-II sensor overestimates PM levels by 1.5 to 2.2, aligning with U.S. EPA findings. Applying a correction equation can effectively reduce this bias and improve data accuracy. Additionally, PA-II data is a more reliable indicator of smoke events than dust events. Future work will apply these correction factors to a network of PA-II sensors to monitor indoor and outdoor wood smoke levels in the homes of individuals with asthma.