AQS 1 Co-Location Field Trial at Tengtou, Zhejiang

August 2016 to April 2017

Authors

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Acknowledgements

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- Mr Shawn Xu of Digital Sensing Technology Co. Ltd for the installation and operation of the AQS 1.
1 Introduction

The Aeroqual AQS 1 is an ambient air quality monitor that combines particulate matter and gas pollutant measurement in a compact package that can be quickly deployed.

A co-location trial of an Aeroqual AQS 1 and a reference air monitoring station was conducted in Tengtou, Zhejiang, China. The AQS 1 was installed on the roof of the Zhejiang Environmental Monitoring Board’s (EMB) Tengtou air monitoring station by Shanghai Digital Sensing Technology Co., Ltd.

The AQS 1 measured ozone (O₃) and PM₂.₅. Its internal temperature was also logged for diagnostic purposes. The reference station measured criteria pollutants and meteorological parameters including ambient temperature and relative humidity.

This report presents the results of the co-location trial for the nine month period 01 August 2016 to 30 April 2017. It contains basic statistical information, line graphs and scatter plots. From the results of the comparison the coefficient of determination ($r^2$) has been calculated for 1-hour and 24-hour averaging periods.

Field maintenance was performed on the AQS 1 three times during the trial period. The AQS 1 was not calibrated during the field trial and data collected was based on the factory calibration of the unit. Reference station data was obtained from Zhejiang EMB; this data was used as received and no adjustments were applied.
1.1 Site location

The AQS 1 was installed on the rooftop of the Zhejiang Environmental Monitoring Board air monitoring site located 22 km southwest of downtown Ningbo and 100 km south of Shanghai. There was an agricultural area to the west and a residential area to the east. (Figure 1). The closest main road was 360 m to the south.

Figure 1: Aerial view of the area surrounding the Tengtou air monitoring site (indicated by blue arrow)

1.2 Significant events

During the monitoring period there were several significant weather events. The Zhejiang province was hit by several major storms including typhoons Meranti (September 2016) and Haima (October 2016). During these events the AQS 1 was able to perform with no effect and withstood the extreme conditions.
2 Results

Basic statistics and correlation coefficients are displayed in Table 1. Graphs of data are displayed in Figures 2 to 8.

<table>
<thead>
<tr>
<th>Average</th>
<th>Parameter</th>
<th>Minimum</th>
<th>Average</th>
<th>Maximum</th>
<th>Data Capture (%)</th>
<th>Correlation coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-hour</td>
<td>AQS 1 O\textsubscript{3} (ppb)</td>
<td>0.0</td>
<td>31.9</td>
<td>126.8</td>
<td>99</td>
<td>0.95</td>
</tr>
<tr>
<td></td>
<td>Reference O\textsubscript{3} (ppb)</td>
<td>0.9</td>
<td>30.9</td>
<td>138.2</td>
<td>96</td>
<td></td>
</tr>
<tr>
<td>24-hour</td>
<td>AQS 1 PM\textsubscript{2.5} (µg/m\textsuperscript{3})</td>
<td>16.7</td>
<td>32.1</td>
<td>74.6</td>
<td>100</td>
<td>0.73</td>
</tr>
<tr>
<td></td>
<td>Reference PM\textsubscript{2.5} (µg/m\textsuperscript{3})</td>
<td>6.5</td>
<td>32.1</td>
<td>73.6</td>
<td>96</td>
<td></td>
</tr>
</tbody>
</table>
Figure 2: Hourly ozone comparison for 01 August 2016 to 30 April 2017
Figure 3: Hourly ozone scatter plot for 01 August 2016 to 30 April 2017

\[
[\text{Ref } O_3] = 0.95[\text{AQS } O_3] + 0.076
\]

\[R^2 = 0.95\]
Figure 4: Scatter plots of the hourly $O_3$ difference (reference minus AQS 1 data) vs ambient temperature and relative humidity for 01 August 2016 to 30 April 2017
Figure 5: 24-Hourly PM$_{2.5}$ comparison for 01 August 2016 to 30 April 2017
Figure 6: 24-Hourly PM$_{2.5}$ scatter plot for 01 August 2016 to 30 April 2017

\[ \text{Ref PM}_{2.5} = 1.0 \times \text{AQS PM}_{2.5} + 0.04 \]

\[ R^2 = 0.73 \]
Figure 7: Scatter plots of the hourly PM$_{2.5}$ difference (reference minus AQS 1 data) vs ambient temperature and relative humidity for 01 August 2016 to 30 April 2017
Figure 8: 1-Hourly reference ambient temperature and AQS 1 internal temperature for 01 August 2016 to 30 April 2017
3 Evaluation

The Aeroqual AQS 1 achieved a data capture rate of 100 % and performed without faults over the period of the trial. The O\textsubscript{3} and PM\textsubscript{2.5} was calibrated by using 1 week of reference instrument data. The O\textsubscript{3} module was calibrated four times and the PM\textsubscript{2.5} was calibrated once during the reporting period.

The 1-hour average O\textsubscript{3} concentrations measured by the AQS 1 showed excellent correlation with the reference O\textsubscript{3} analyser with an $r^2 = 0.95$. The slope was 0.95 with an offset of 0.08 ppb.

The 24-hour average PM\textsubscript{2.5} concentrations measured by the AQS 1 also showed a good correlation to the reference PM\textsubscript{2.5} instrument with an $r^2 = 0.73$. The slope was 1.0 with an offset of 0.04 µg/m\textsuperscript{3}.

The AQS 1 was exposed to hourly ambient temperatures that ranged from -2.4 to 37.6 °C and hourly relative humidity that ranged from 20.2 to 100.0 %. No significant temperature or relative humidity interference effects were observed on either the AQS 1 O\textsubscript{3} or PM\textsubscript{2.5} measurements (Figure 4 and Figure 7). In addition, the AQS 1 was not affected by extreme weather events during the reporting period.

In conclusion, the AQS 1 performed consistently well over the 9 month test period with all measurements closely matching those of the reference station values.
Appendix

A.1 Instrument Maintenance

<table>
<thead>
<tr>
<th>Date</th>
<th>Maintenance performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>30/08/16</td>
<td>Leak check performed. Flows checked and adjusted. PM$_{2.5}$ sample and in-line gas filters changed.</td>
</tr>
<tr>
<td>27/10/16</td>
<td>PM$_{2.5}$ sample and purge, and in-line gas filters changed.</td>
</tr>
<tr>
<td>11/04/17</td>
<td>PM$_{2.5}$ sample and purge, and in-line gas filters changed. Flows checked</td>
</tr>
</tbody>
</table>

A.2 Data Validation

Reference data

Calibration data (automatic and manual calibration/maintenance) from throughout the period was removed. No other adjustments were made.

AQS 1 data

Summary of data validation:

<table>
<thead>
<tr>
<th>Period</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>01/08/16 00:00 to 30/04/17 23:59</td>
<td>PM$_{2.5}$ calibrated based on reference data comparison during the period 01/08/16 00:00 – 07/08/16 23:59</td>
</tr>
<tr>
<td>01/08/16 00:00 to 30/08/16 09:00</td>
<td>Ozone calibrated based on reference data comparison during the period 01/08/16 00:00 – 07/08/16 23:59</td>
</tr>
<tr>
<td>30/08/16 10:00 to 12/09/16 19:00</td>
<td>Ozone calibrated based on reference data comparison during the period 31/08/16 00:00 – 06/09/16 23:59</td>
</tr>
<tr>
<td>12/09/16 20:00 to 05/01/17 15:00</td>
<td>Ozone calibrated based on reference data comparison during the period 13/09/16 00:00 – 19/09/16 23:59</td>
</tr>
<tr>
<td>01/12/16 00:00 to 13/02/17 08:05</td>
<td>PM$_{2.5}$ linear baseline correction (auto-zero was turned off during this period)</td>
</tr>
<tr>
<td>05/01/17 16:00 to 30/04/17 23:59</td>
<td>Ozone calibrated based on reference data comparison during the period 06/01/17 00:00 – 12/01/17 23:59</td>
</tr>
</tbody>
</table>

Calibration (automatic and manual) and maintenance data from throughout the period was removed.