Field Evaluation
Aeroqual AQY (v0.5)
Background

From 12/22/2017 to 03/27/2018, three Aeroqual AQY (Version 0.5) multi-sensor units were deployed in Rubidoux and run side-by-side South Coast AQMD Federal Equivalent Method (FEM) and Federal Reference Method (FRM) instruments measuring the same pollutants

**Aeroqual AQY (3 units tested):**
- Sensors: Ozone – Gas Sensitive Semiconductor (GSS) (non-FEM);
  NO$_2$ – Gas Sensitive Electrochemical (GSE) (non-FEM);
  PM$_{2.5}$ – Laser Particle Counter (LPC) (non-FEM), (model SDS011 by Nova Fitness)
- Each unit measures: O$_3$ (ppb), NO$_2$ (ppb), PM$_{2.5}$ ($\mu$g/m$^3$), T (degrees C), RH (%)
- Unit cost: ~$3,000 (includes 2-yr tech support + cloud data software license)
- Time resolution: 1-min
- Units IDs: AQY 130, AQY 131 (AQY 134), AQY 132
  (On 2/15/2018, entire unit AQY 131 was replaced by unit AQY 134 due to faulty NO$_2$ sensor)

**SCAQMD Reference instruments:**
- O$_3$ instrument (FEM); cost: ~$7,000
- Time resolution: 1-min
- NO$_x$ instrument (FRM); cost: ~$11,000
- Time resolution: 1-min
- GRIMM (FEM PM$_{2.5}$); cost: $25,000 and up
  Time resolution: 1-min
- MetOne BAM (FEM PM$_{2.5}$); cost: ~$20,000
  Time resolution: 1-hr
- Met station (T, RH, P, WS, WD); cost: ~$5,000
  Time resolution: 1-min
Ozone (\(O_3\)) in AQY
Data validation & recovery

- Basic QA/QC procedures were used to validate the collected data (i.e., obvious outliers, negative values, and invalid data-points were eliminated from the data-set).
- Data recovery for ozone in the four AQYs was high (i.e., 92% for AQY 130; 76% for AQY 131; 97% for AQY 132 and 100% for AQY 134).

Aeroqual AQY; Intra-model variability

- Low measurement variability was observed between the two AQY units (130, 132) for ozone during the entire deployment period.
Aeroqual AQY vs FEM (Ozone; 5-min mean)

- AQY Ozone measurements showed very strong correlations with the corresponding FEM data ($R^2 \sim 0.96$)

- Overall, the AQY sensors underestimated ozone concentration as measured by the FEM instrument

- The AQYs seem to track well the diurnal ozone variations recorded by the FEM instrument

On 2/15/18, AQY 131 was replaced by AQY 134
Aeroqual AQY vs FEM (Ozone; 1-hr mean)

- AQY Ozone measurements showed very strong correlations with the corresponding FEM data ($R^2 \approx 0.96$)
- Overall, the AQY sensors underestimated ozone concentration as measured by the FEM instrument
- The AQYs seem to track well the diurnal ozone variations recorded by the FEM instrument

On 2/15/18, AQY 131 was replaced by AQY 134
Aeroqual AQY vs FEM (Ozone; 8-hr mean)

- AQY Ozone measurements showed very strong correlations with the corresponding FEM data ($R^2 \approx 0.96$)
- Overall, the AQY sensors underestimated ozone concentration as measured by the FEM instrument
- The AQYs seem to track well the diurnal ozone variations recorded by the FEM instrument

On 2/15/18, AQY 131 was replaced by AQY 134
Nitrogen Dioxide (NO$_2$) in AQY
NO$_2$ Data Handling

During this AQ-SPEC field evaluation, Aeroqual corrected and calculated NO$_2$ in all four units, using two different approaches:

1$^{st}$ approach (in this report, pollutant referred to as NO$_2$):
- NO$_2$ with correction for O$_3$ bias using AQY ozone data in real-time
- Calculation by on-instrument Aeroqual algorithm

2$^{nd}$ approach (in this report, pollutant referred to as NO$_2$ V2)
- NO$_2$ with correction for O$_3$ and RH bias using AQY ozone and AQY RH data in real-time
- Calculation by new on-instrument Aeroqual algorithm

To better assist in understanding the procedures mentioned above, Aeroqual has shared all related proprietary information with AQ-SPEC
Data validation & recovery

- Basic QA/QC procedures were used to validate the collected data (i.e., obvious outliers, negative values, and invalid data-points were eliminated from the data-set).
- Data recovery for NO$_2$ in the four AQYs was high (i.e., 98% for AQY 130; 95% for AQY 131; 85% for AQY 132 and 92% for AQY 134).

Aeroqual AQY; Intra-model variability

- Moderate measurement variability was observed between the two AQY units (130, 132) for nitrogen dioxide during the entire deployment period.
Aeroqual AQY vs FRM (NO$_2$; 5-min mean)

On 2/15/18, AQY 131 was replaced by AQY 134

- AQY NO$_2$ measurements in AQYs 130 and 132 showed weak correlations with the corresponding FRM data ($R^2 \approx 0.499$)

- Overall, the AQY sensors underestimated NO$_2$ concentration as measured by the FRM instrument

- The AQYs seem to track the diurnal NO$_2$ variations recorded by the FRM instrument
Data validation & recovery

• Basic QA/QC procedures were used to validate the collected data (i.e., obvious outliers, negative values, and invalid data-points were eliminated from the data-set)
• Data recovery for \( \text{NO}_2 \text{ V2} \) in the four AQYs was high (i.e., 98% for AQY 130; 99% for AQY 131; 97% for AQY 132 and 99% for AQY 134).

Aeroqual AQY; Intra-model variability

• Very low measurement variability was observed between the two AQY units (130, 132) for nitrogen dioxide (V2) during the entire deployment period.
Aeroqual AQY vs FRM (NO$_2$; 5-min mean)

- AQY NO$_2$ measurements in AQYs 130 and 132 showed strong correlations with the corresponding FRM data ($R^2 \sim 0.77$)

- The two AQYs seem to track the diurnal NO$_2$ variations recorded by the FRM instrument

On 2/15/18, AQY 131 was replaced by AQY 134
Aeroqual AQY vs FRM (NO$_2$; 1-hr mean)

- AQY NO$_2$ measurements in AQYs 130 and 132 showed strong correlations with the corresponding FRM data ($R^2 \approx 0.79$)

- The two AQYs seem to track the diurnal NO$_2$ variations recorded by the FRM instrument.

On 2/15/18, AQY 131 was replaced by AQY 134.
Aeroqual AQY vs FRM (NO$_2$; 24-hr mean)

- AQY NO$_2$ measurements in AQYs 130 and 132 showed strong correlations with the corresponding FRM data ($R^2 \sim 0.83$)
- The two AQYs seem to track the diurnal NO$_2$ variations recorded by the FRM instrument

On 2/15/18, AQY 131 was replaced by AQY 134
PM$_{2.5}$ in AQY
Basic QA/QC procedures were used to validate the collected data (i.e., obvious outliers, negative values, and invalid data-points were eliminated from the data-set).

AQY PM$_{2.5}$ was corrected based on AQY RH data in real-time.

Data recovery for PM$_{2.5}$ in the four AQYs was excellent (i.e., 99% for AQY 130; 100% for AQY 131, AQY 132 and AQY 134).

Aeroqual AQY; Intra-model variability

Very low measurement variability was observed between the two AQY units (130, 132) for PM$_{2.5}$ during the entire deployment period.
Data validation & recovery

- Basic QA/QC procedures were used to validate the collected FEM data (i.e. obvious outliers, negative values and invalid data-points were eliminated from data-set)
- PM$_{2.5}$ data recovery was 68% for the GRIMM and 88% for the BAM.

Equivalent methods: BAM vs GRIMM

- Excellent agreement between the two equivalent methods for PM$_{2.5}$
• AQY PM$_{2.5}$ measurements in AQYs 130 and 132 showed strong correlations with the corresponding FEM GRIMM data ($R^2 \approx 0.86$)

• Overall, the AQY sensors underestimated PM$_{2.5}$ concentration as measured by the FEM instrument

• The two AQYs seem to track well the diurnal PM$_{2.5}$ variations recorded by the FEM GRIMM instrument
Aeroqual AQY vs FEM (GRIMM PM$_{2.5}$; 1-hr mean)

- AQY PM$_{2.5}$ measurements in AQYs 130 and 132 showed strong correlations with the corresponding FEM GRIMM data ($R^2 \sim 0.86$)
- Overall, the AQY sensors overestimated PM$_{2.5}$ concentration as measured by the FEM instrument
- The two AQYs seem to track well the diurnal PM$_{2.5}$ variations recorded by the FEM GRIMM instrument

On 2/15/18, AQY 131 was replaced by AQY 134
AQY PM$_{2.5}$ measurements in AQYs 130 and 132 showed very strong correlations with the corresponding FEM GRIMM data ($R^2 \sim 0.92$)

- The two AQYs seem to track well the diurnal PM$_{2.5}$ variations recorded by the FEM GRIMM instrument

On 2/15/18, AQY 131 was replaced by AQY 134
Aeroqual AQY vs FEM (BAM PM$_{2.5}$; 1-hr mean)

- AQY PM$_{2.5}$ measurements in AQYs 130 and 132 showed strong correlations with the corresponding FEM BAM data ($R^2 \sim 0.84$)
- Overall, the AQY sensors overestimated PM$_{2.5}$ concentration as measured by the FEM instrument
- The two AQYs seem to track the diurnal PM$_{2.5}$ variations recorded by the FEM BAM instrument

On 2/15/18, AQY 131 was replaced by AQY 134
Aeroqual AQY vs FEM (BAM PM$_{2.5}$; 24-hr mean)

- AQY PM$_{2.5}$ measurements in AQYs 130 and 132 showed very strong correlations with the corresponding FEM BAM data ($R^2 \approx 0.90$)
- Overall, the AQY sensors overestimated PM$_{2.5}$ concentration as measured by the FEM instrument
- The two AQYs seem to track the diurnal PM$_{2.5}$ variations recorded by the FEM BAM instrument

On 2/15/18, AQY 131 was replaced by AQY 134
• AQY Temp measurements in AQYs 130 and 132 showed very strong correlations with the corresponding South Coast AQMD Met Station sensor ($R^2 \sim 0.93$)

• Overall, the AQY sensors overestimated ambient Temp as measured by the South Coast AQMD Met Station sensor

• The two AQYs seem to track the diurnal Temp variations recorded by the South Coast AQMD Met station sensor
AQY RH measurements in AQYs 130 and 132 showed very strong correlations with the corresponding South Coast AQMD Met Station sensor ($R^2 \approx 0.96$).

Overall, the AQY sensors underestimated RH as measured by the South Coast AQMD Met Station sensor.

The two AQYs seem to track the diurnal RH variations recorded by the South Coast AQMD Met station sensor.

On 2/15/18, AQY 131 was replaced by AQY 134.
Discussion

• With the exception of a faulty NO$_2$ sensor in one of the three units (AQY 131), the Aeroqual AQY v0.5 multi-sensor units (AQY 130 and 132) showed:
  ➢ Minimal down-time: data recovery from each unit was higher than 90%
  ➢ Low intra-model variability for all measured pollutants
• During the entire field deployment testing period:
  ➢ Ozone sensors showed very strong correlations ($R^2 \sim 0.96$, 5-min mean) with the reference instrument and underestimated the corresponding FEM Ozone data
  ➢ NO$_2$ V2 sensors showed strong correlations ($R^2 \sim 0.77$, 5-min mean) with the reference instrument
  ➢ PM$_{2.5}$ sensors showed strong correlations (GRIMM: $R^2 \sim 0.86$, 5-min mean and BAM: $R^2 \sim 0.84$, 1-hr mean) with the reference instrument, underestimated the corresponding FEM GRIMM PM$_{2.5}$ data and overestimated the FEM BAM PM$_{2.5}$ data
  ➢ Temp and RH sensors showed very strong correlations (T: $R^2 \sim 0.93$, 5-min mean and RH: $R^2 \sim 0.96$, 5-min mean) with the South Coast AQMD Met Station sensors, overestimated and underestimated the corresponding South Coast AQMD Met Station Temp and RH sensors, respectively
  ➢ No sensor calibration was performed by AQ-SPEC prior to the beginning of this field testing
• Laboratory chamber testing is necessary to fully evaluate the performance of these sensors under controlled T and RH conditions, and known target and interferent pollutants concentrations.
  • These results are still preliminary