Field Evaluation of Vaisala Air Quality Transmitter AQT410 v.1.15
Background

- From 3/06/2018 to 5/03/2018, three Vaisala AQT410 v.1.15 sensors were deployed at the South Coast AQMD stationary ambient monitoring site in Rubidoux and were run side-by-side with reference instruments measuring the same pollutants.

**Vaisala AQT410 v.1.15 (3 units tested):**
- Gas sensors (electrochem gas sensor; non-FRM/FEM)
- Each unit measures NO₂ (ppm), SO₂ (ppm), CO (ppm), Ozone (ppm), ambient air temperature (degree F), relative humidity (%), and pressure (mbar)
- Unit cost: ~$3,700
- Time resolution: 1-min
- Units IDs:
  - 0006
  - 0001
  - 0002

**South Coast AQMD Reference instruments:**
- CO instrument; FRM, cost: ~$10,000
  - Time resolution: 1-min
- NOx instrument; FRM NO₂, cost: ~$11,000
  - Time resolution: 1-min
- O₃ instrument; FEM, cost: ~$7,000
  - Time resolution: 1-min
- SO₂ instrument; FEM, cost: ~$11,000
  - Time resolution: 1-min
- Met Station (T, RH, P, WS, WD); cost: ~$5,000
  - Time resolution: 1-min
Differences between Vaisala AQT410 v.1.11 and v.1.15

Vaisala AQT410 v.1.11 had previously been evaluated in the field from 7/14/2017 to 8/22/2017 (Vaisala AQT410 Field Evaluation Report)
- Hardware remains the same for both Vaisala AQT410 v.1.11 and v.1.15

Key firmware updates from v.1.11 to v.1.15
- Calibration parameters updated to new calibration system for baseline compensation of the gas measurements
- Instrument learning period increased based on tests at high concentrations
- Bug fix for temperature compensation of gas measurements at high ambient temperatures
- Reliability of use improved for the device and Modbus communications
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 was over 96% for all units/pollutants tested, except for ozone, which had a data recovery of >85%.

Vaisala AQT410; intra-model variability

- Low intra-model variability was observed for CO and Ozone, from all Vaisala AQT410 sensors (5.4% and 9.5%, respectively)
- NO₂ levels showed a relatively higher variation among the tested AQT410 sensors (11.6%)
- SO₂ evaluation was not included in this report due to its concentrations being too low to be reliably detected by the SO₂ FEM instrument
Vaisala AQT410 vs FRM (NO$_2$; 5-min mean)

- AQT410 sensors showed weak-to-moderate correlations with the corresponding FRM NO$_2$ data ($0.43 < R^2 < 0.61$)
- Overall, the AQT410 sensors overestimated NO$_2$ concentration as measured by the FRM instrument
- AQT410 sensors seemed to track the NO$_2$ diurnal variations as recorded by the FRM instrument
Vaisala AQT410 vs FRM (CO; 5-min mean)

- AQT410 sensors showed strong correlations with the corresponding FRM CO data (0.80<R²<0.83)
- AQT410 sensors seemed to track well the diurnal CO variation recorded by the FRM instrument
AQT410 sensors showed moderate-to-strong correlations with the corresponding FEM ozone data (0.66<R²<0.82).

Overall, the AQT410 sensors overestimated ozone concentration as measured by the FEM instrument.

AQT410 sensors seemed to track well the diurnal ozone variations recorded by the FEM instrument.
Vaisala AQT410 vs South Coast AQMD Met Station (Temp; 5-min mean)

- The AQT410 temperature measurements showed very strong correlations with the corresponding South Coast AQMD Met Station data ($R^2 > 0.97$).
- Overall, the AQT410 temperature measurements overestimated the corresponding South Coast AQMD Met Stations data.
- AQT410 sensors seemed to track well the diurnal Temp variations recorded by the South Coast AQMD Met station.
The AQT410 RH measurements showed very strong correlations with the corresponding South Coast AQMD Met Station data ($R^2 > 0.98$).

AQT410 sensors seemed to track well the diurnal RH variations recorded by the South Coast AQMD Met station sensor.
AQT410 sensors showed weak-to-moderate correlations with the corresponding FRM data ($0.44 < R^2 < 0.63$) Overall, the AQT410 sensors overestimated NO$_2$ concentration as measured by the FRM instrument The AQT410 sensors seemed to track the NO$_2$ diurnal variations as recorded by the FRM instruments
Vaisala AQT410 vs FRM (CO; 1-hr mean)

- AQT410 sensors showed strong correlations with the corresponding FRM CO data (0.85<R²<0.88)
- AQT410 sensors seemed to track the CO diurnal variations as recorded by the FRM instrument
Vaisala AQT410 vs FEM (Ozone; 1-hr mean)

- AQT410 sensors showed moderate-to-strong correlations with the corresponding FEM data (0.66 < $R^2$ < 0.82)
- Overall, the AQT410 sensors overestimated ozone concentration as measured by the FEM instrument
- AQT410 track well the diurnal $O_3$ variations recorded by the FEM instrument
Vaisala AQT410 vs FRM (NO$_2$; 24-hr mean)

- AQT410 sensors showed very weak-to-weak correlations with the corresponding FRM NO$_2$ data (0.29<$R^2$<0.50)
- Overall, the AQT410 sensors overestimated NO$_2$ concentration as measured by the FRM instrument
- The AQT410 sensors seemed to track the NO$_2$ diurnal variations as recorded by the FRM instrument

![Graph showing correlations and diurnal variations](image-url)
Vaisala AQT410 vs FRM (CO; 24-hr mean)

- AQT410 sensors showed strong correlations with the corresponding FRM CO data ($0.81 < R^2 < 0.87$)
- Overall, the AQT410 sensors overestimated CO concentration as measured by the FRM instrument
- AQT410 sensors seemed to track the CO variation as recorded by the FRM instrument
Vaisala AQT410 vs FEM (Ozone; 24-hr mean)

- AQT410 sensors showed weak-to-moderate correlations with corresponding FEM ozone data ($0.44 < R^2 < 0.69$)
- Overall, the AQT410 sensors overestimated ozone concentration as measured by the FEM instrument
- The AQT410 sensors seemed to track the ozone diurnal variations as recorded by the FRM instrument
Discussion

- Data recovery for **Vaisala AQT410 v.1.15** CO and NO$_2$ sensors was higher than 96%. The Ozone sensors had 85% data recovery.
- The three sensors showed low intra-model variability for CO and O$_3$ and moderate intra-model variability for NO$_2$.

- During the field deployment testing period:
  - Ozone sensors showed moderate-to-strong correlations (0.66<R$^2$<0.82, 5-min mean) with the reference instrument and overestimated the corresponding FEM Ozone measurements.
  - NO$_2$ sensors showed weak-to-moderate correlations (0.43<R$^2$<0.61, 5-min mean) with the reference instrument and overestimated the corresponding FRM NO$_2$ data.
  - CO sensors showed strong correlations (0.80<R$^2$<0.83, 5-min mean) with the FRM instrument.

- No sensor calibration was performed by South Coast AQMD Staff prior to the beginning of this test.
- Laboratory chamber testing is necessary to fully evaluate the performance of these sensors under known aerosol concentrations and controlled temperature and relative humidity conditions.

- **All results are still preliminary**