

Field Evaluation APIS Sensor



Background

- From 03/13/2019 to 05/14/2019, three **APIS** sensors were deployed at the South Coast AQMD stationary ambient monitoring site in Rubidoux and were run side-by-side with three reference instruments measuring the same pollutants
- APIS (3 units tested):
 - Gas sensors: CO – Alphasense Gas Sensitive Electrochemical (GSE) (**non-FRM**); NO/NO₂/NO_x – Alphasense GSE (**non-FRM**); Ozone – Alphasense GSE (**non-FEM**);
 - Each unit reports: CO (ppb), NO/NO₂/NO_x (ppb), Ozone (ppb), T(°C), RH (%)
 - **Unit cost: \$4,995** (annual subscription includes unit maintenance/replacement + cloud data access)
 - Time resolution: 1-min
 - Units IDs: 1019, 1022, 1026
- South Coast AQMD Reference instruments:
 - CO instrument; **FRM, cost: ~\$10,000**
 - Time resolution: 1-min
 - NO_x instrument; **FRM NO₂, cost: ~\$11,000**
 - Time resolution: 1-min
 - O₃ instrument; **FEM, cost: ~\$7,000**
 - Time resolution: 1-min
 - Met station (T, RH, P, WS, WD); **cost: ~\$5,000**
 - Time resolution: 1-min



Ozone (O₃) in APIS

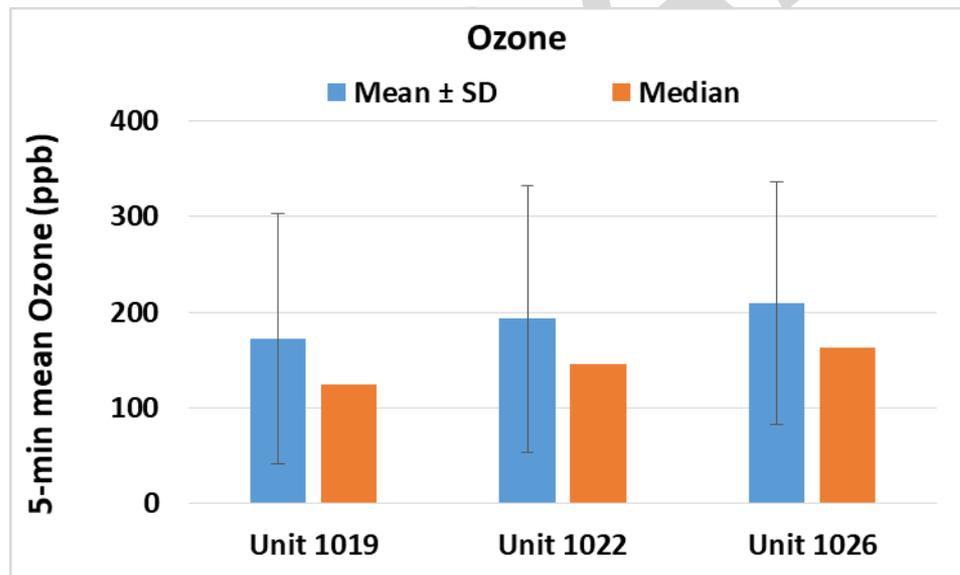
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Data validation & recovery

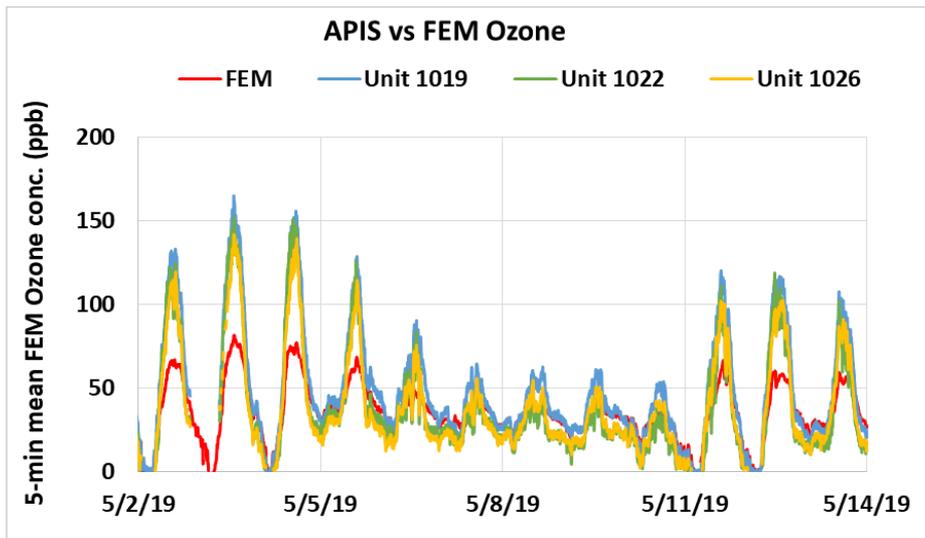
- Basic QA/QC procedures were used to validate the collected data (i.e. obvious outliers, negative values and invalid data-points were eliminated from the data-set)
- Data recovery from units 1019, 1022, and 1026 was 86%, 76% and 82%, respectively.

APIS; intra-model variability

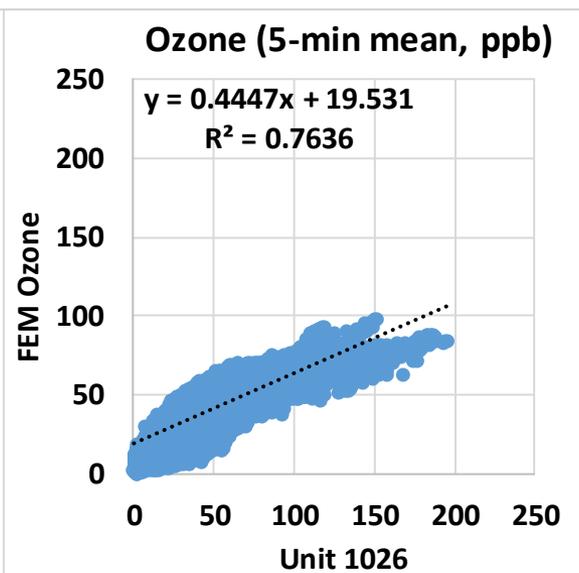
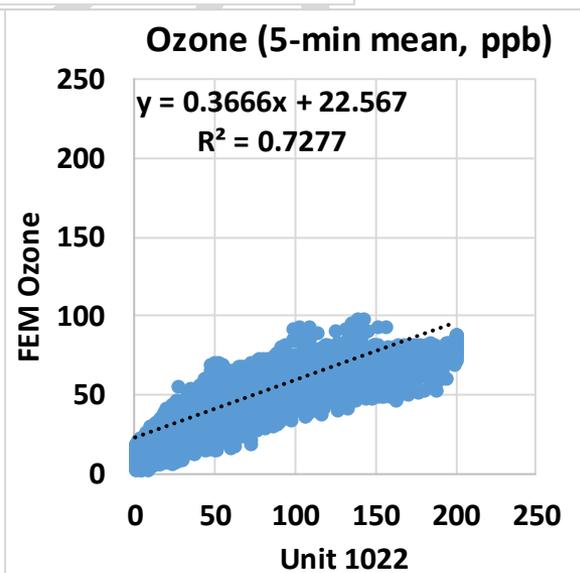
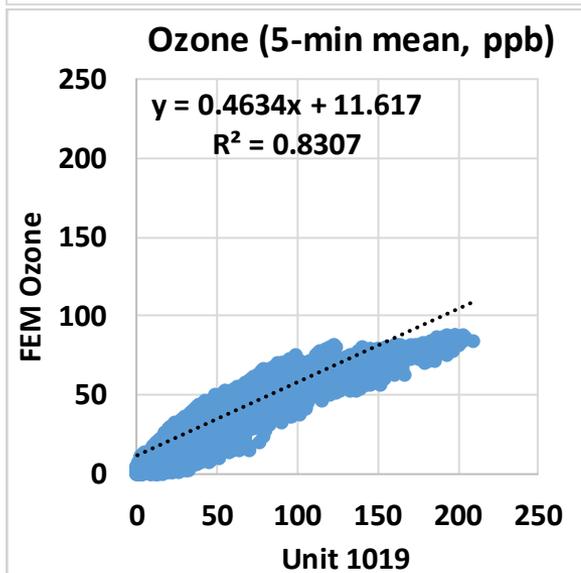
- Low measurement variability (15.6%) was observed between the three APIS units for ozone measurements.



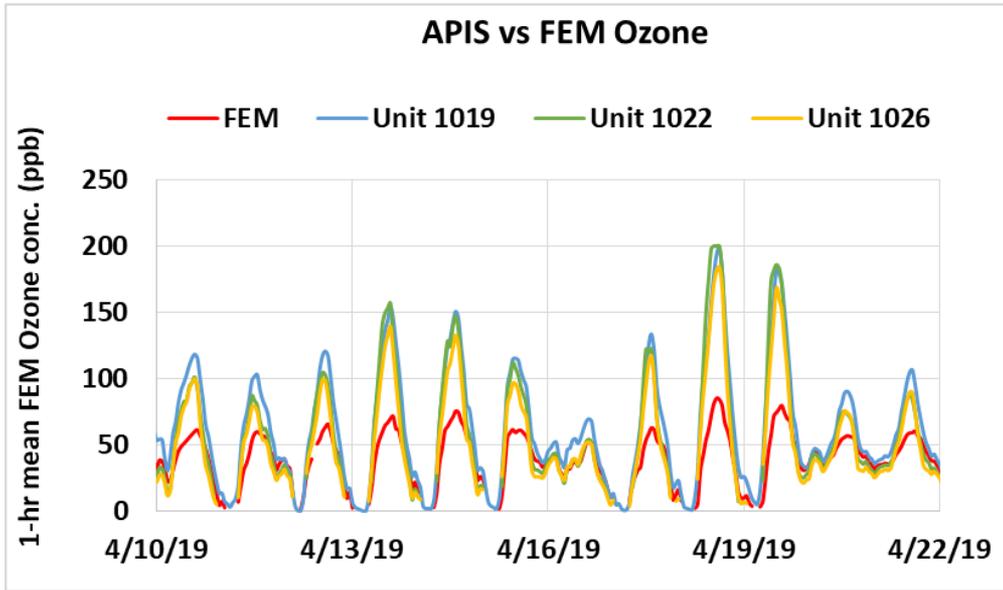
APIS vs FEM (Ozone; 5-min mean)



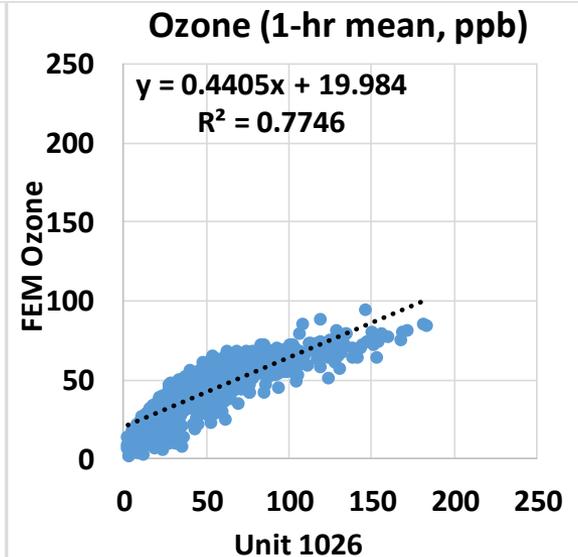
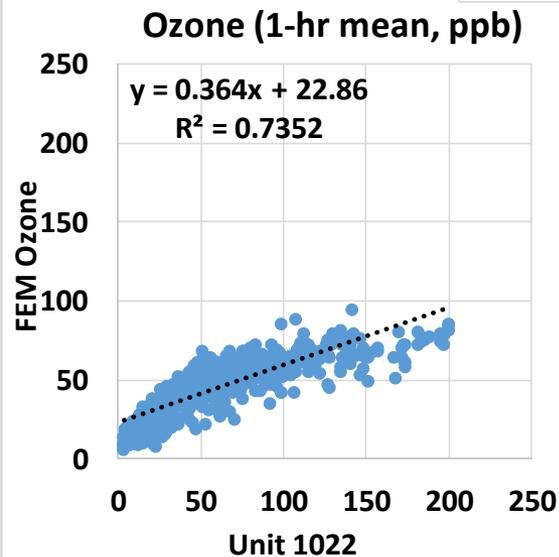
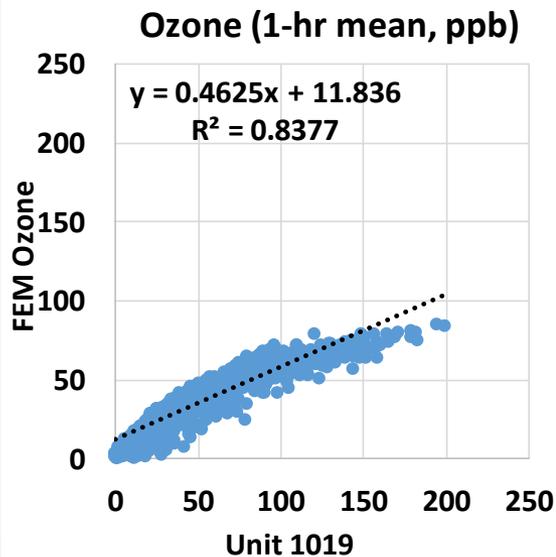
- APIS sensors showed strong correlations with the corresponding FEM ozone data ($R^2 \sim 0.77$)
- Overall, the APIS sensors overestimated ozone concentration as measured by the FEM instrument
- The APIS sensors seemed to track the ozone diurnal variations as recorded by the FEM instrument



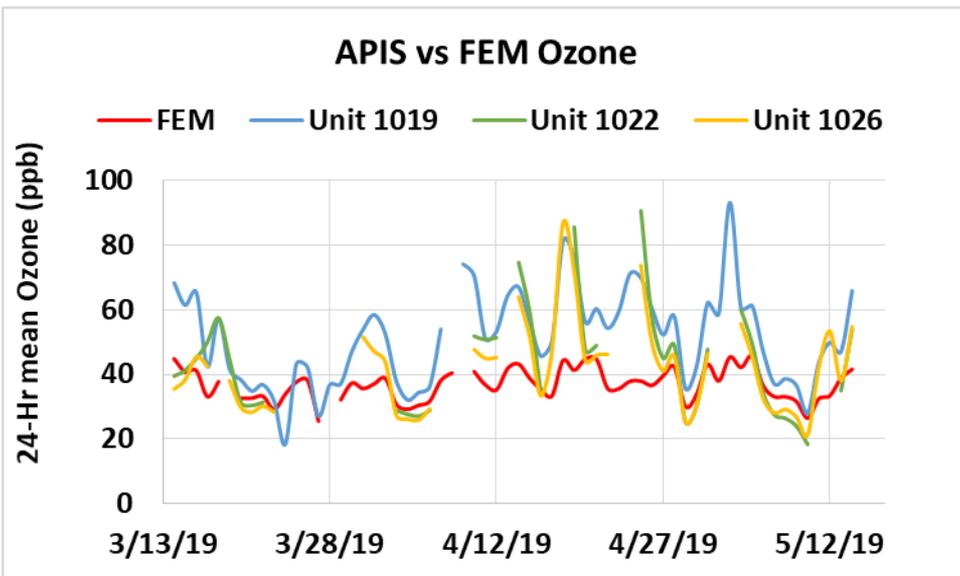
APIS vs FEM (Ozone; 1-hr mean)



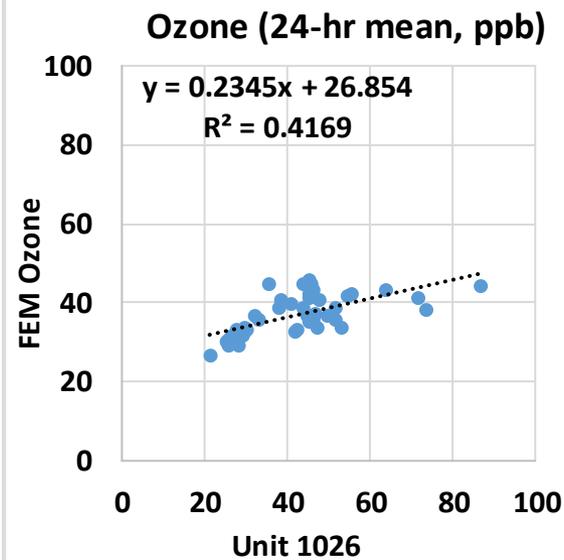
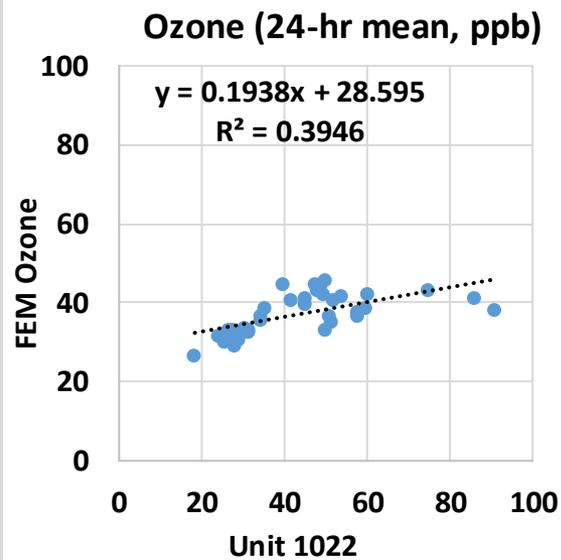
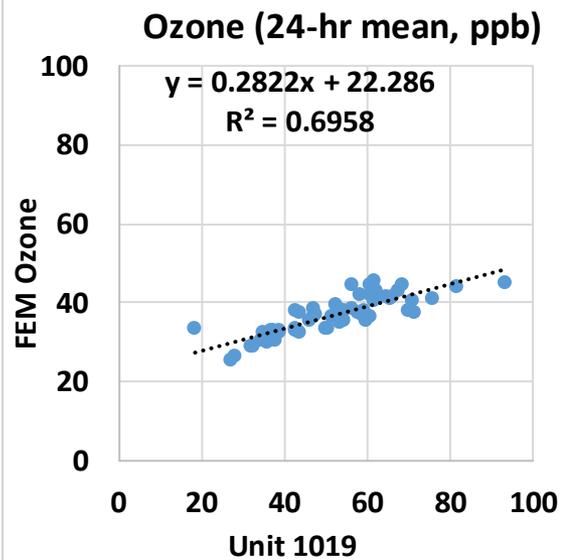
- APIS sensors showed strong correlations with the corresponding FEM ozone data ($R^2 \sim 0.78$)
- Overall, the APIS sensors overestimated ozone concentration as measured by the FEM instrument
- The APIS sensors seemed to track the ozone diurnal variations as recorded by the FEM instrument



APIS vs FEM (Ozone; 24-hr mean)



- APIS sensors showed moderate correlations with the corresponding FEM ozone data ($R^2 \sim 0.50$)
- Overall, the APIS sensors overestimated ozone concentration as measured by the FEM instrument
- The APIS sensors seemed to moderately track the ozone diurnal variations as recorded by the FEM instrument



Nitrogen Monoxide (NO) in APIS

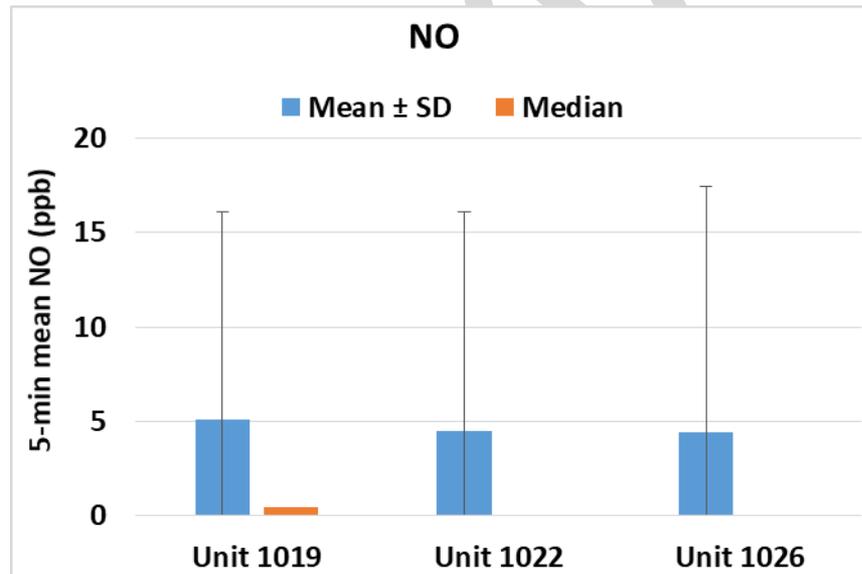
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Data validation & recovery

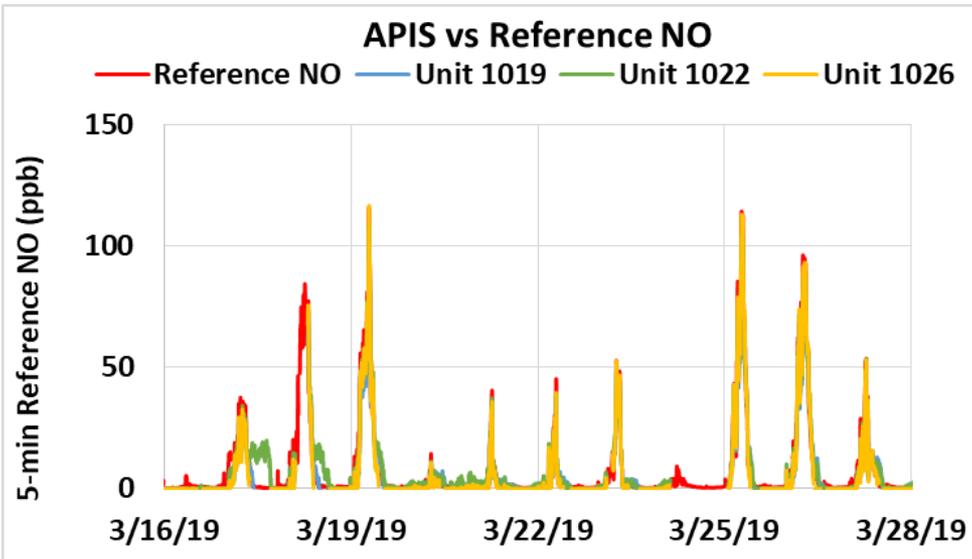
- Basic QA/QC procedures were used to validate the collected data (i.e. obvious outliers, negative values and invalid data-points were eliminated from the data-set)
- Data recovery from units 1019, 1022, and 1026 was 88%, 91% and 78%, respectively.

APIS; intra-model variability

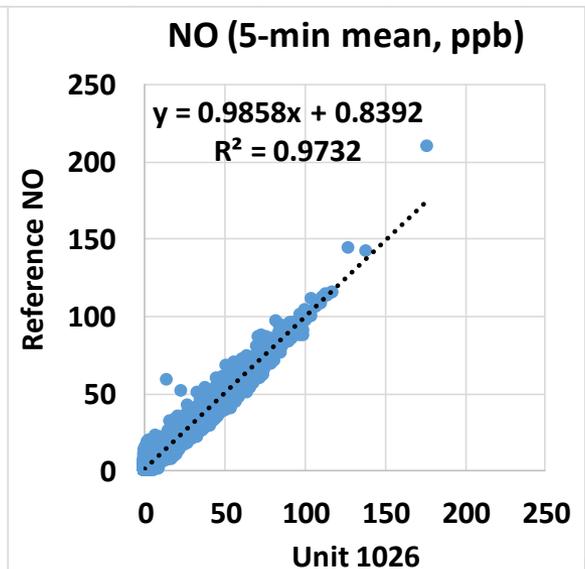
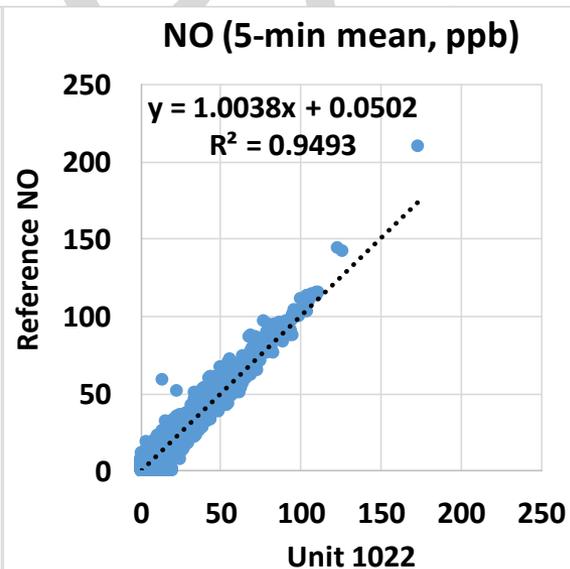
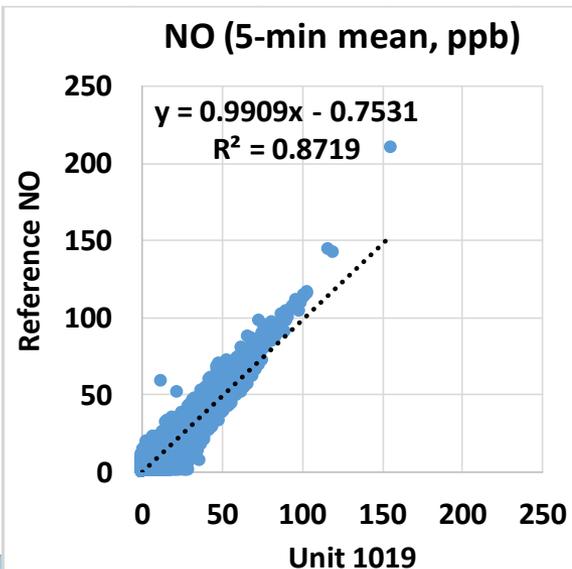
- Low measurement variability (13.5%) was observed between the three APIS units for NO measurements



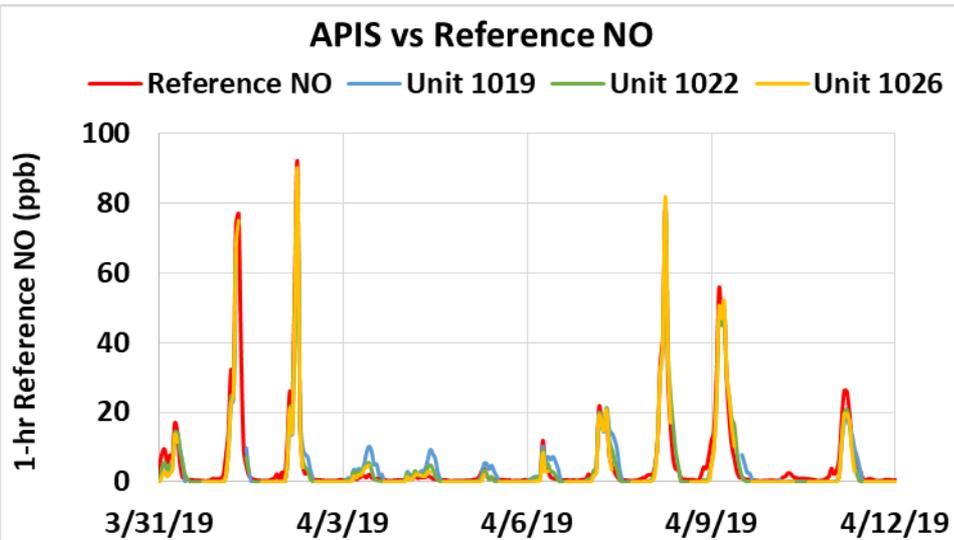
APIS vs Reference NO (NO; 5-min mean)



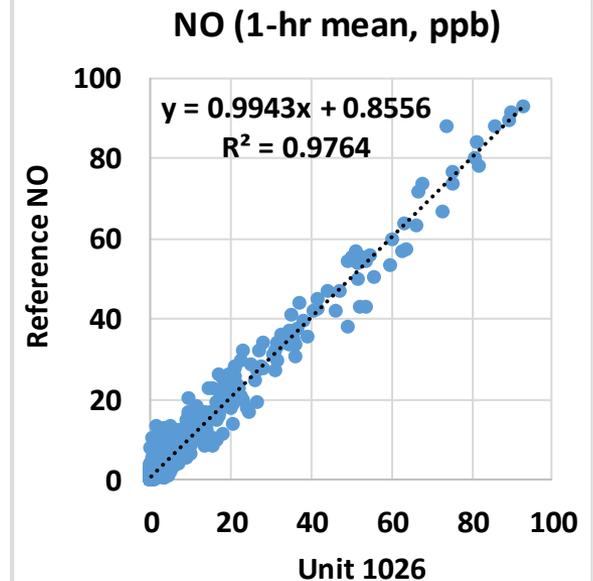
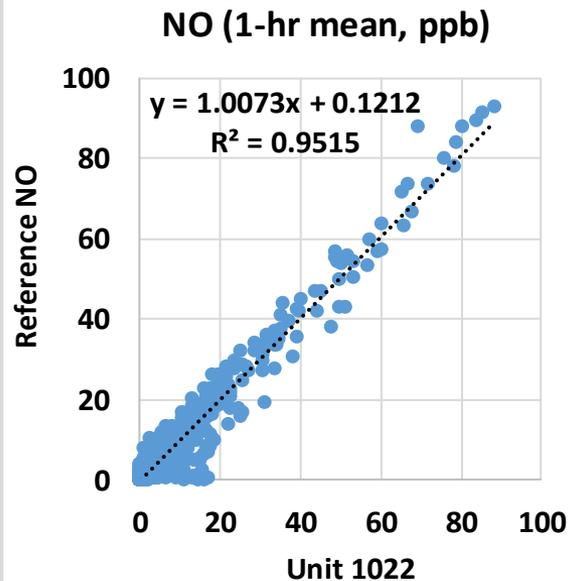
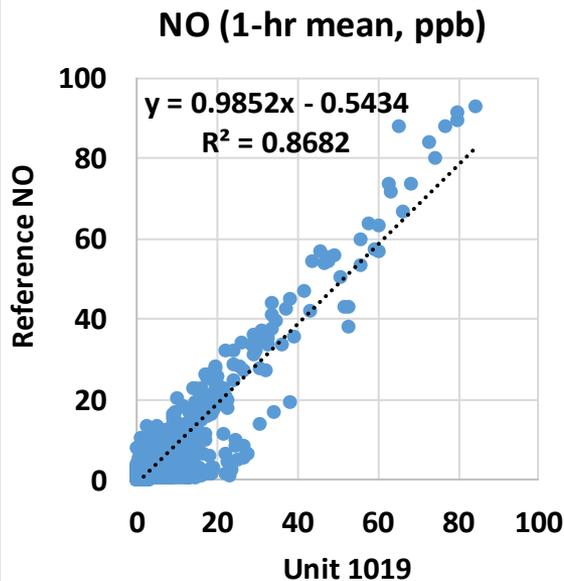
- APIS sensors showed very strong correlations with the corresponding reference NO data ($R^2 \sim 0.93$)
- The APIS sensors seemed to track the NO diurnal variations as recorded by the reference instrument



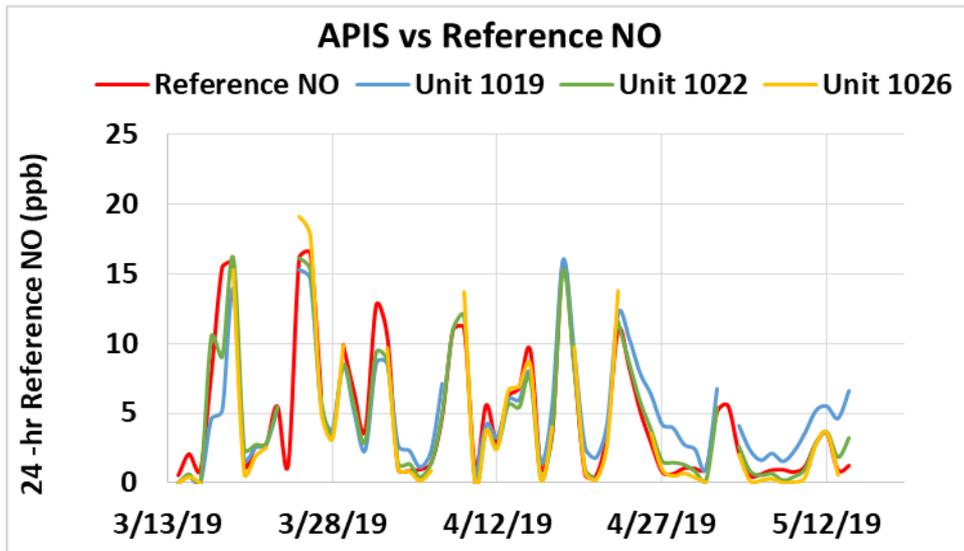
APIS vs Reference NO (NO; 1-hr mean)



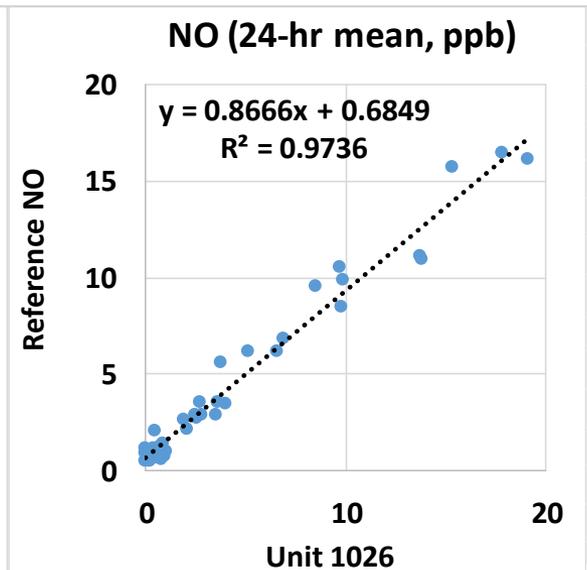
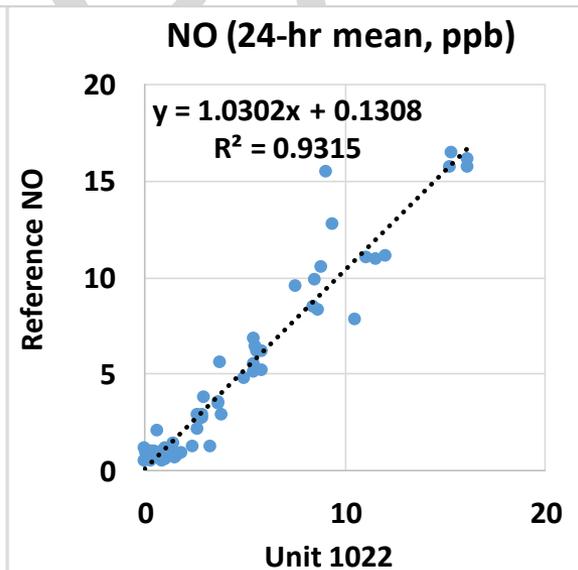
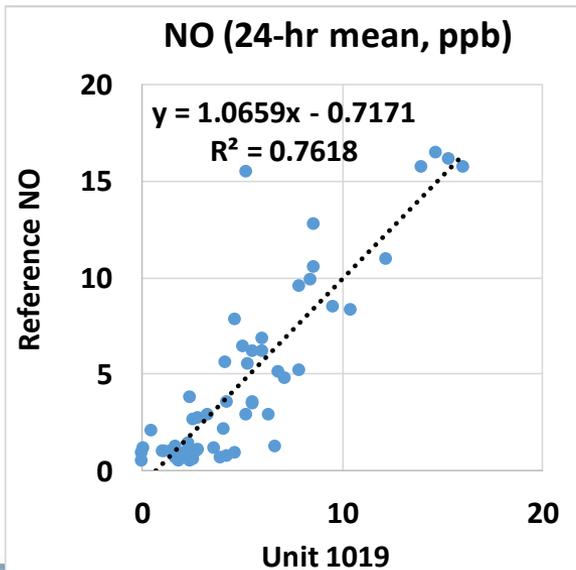
- APIS sensors showed very strong correlations with the corresponding reference NO data ($R^2 \sim 0.93$)
- The APIS sensors seemed to track the NO diurnal variations as recorded by the reference instrument



APIS vs Reference NO (NO; 24-hr mean)



- APIS sensors showed strong correlations with the corresponding reference NO data ($R^2 \sim 0.89$)
- The APIS sensors seemed to track the NO diurnal variations as recorded by the reference instrument



Nitrogen dioxide (NO₂) in APIS

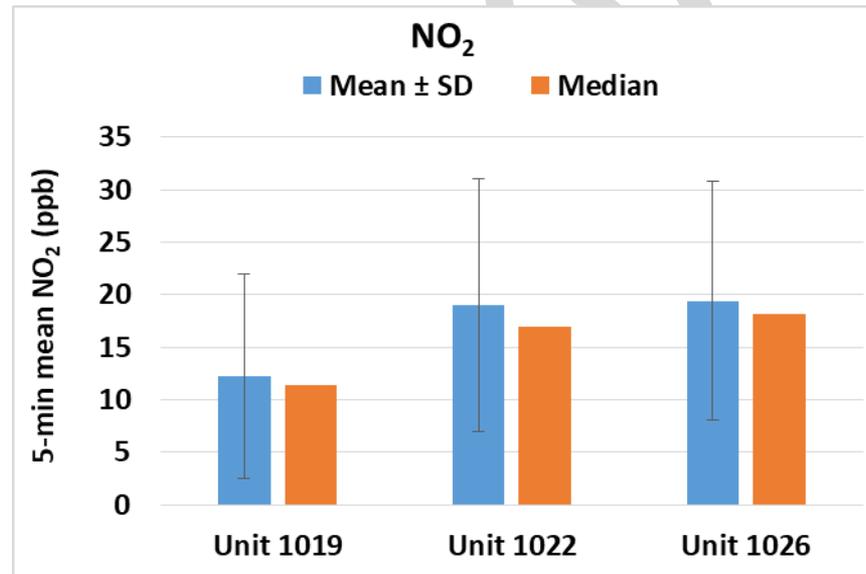
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Data validation & recovery

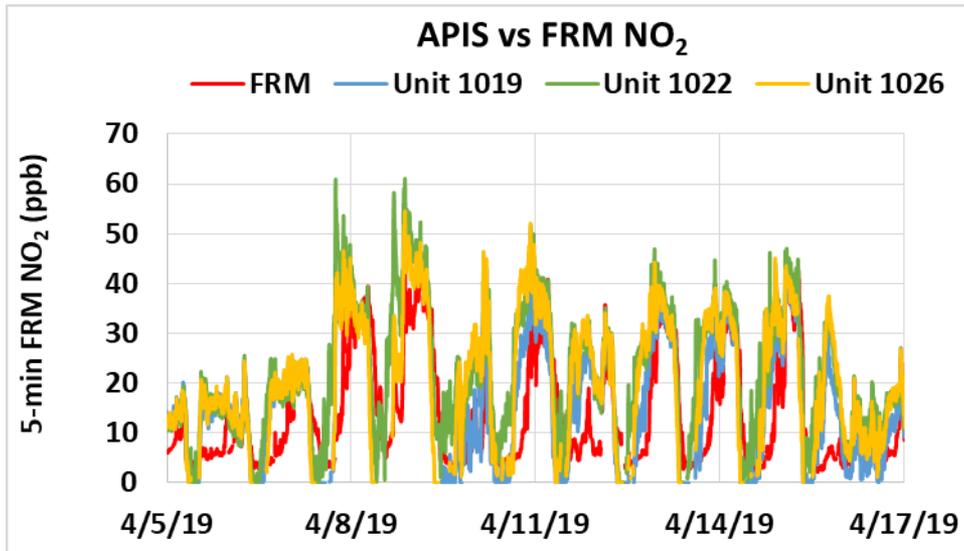
- Basic QA/QC procedures were used to validate the collected data (i.e. obvious outliers, negative values and invalid data-points were eliminated from the data-set)
- Data recovery from units 1019, 1022, and 1026 was 88%, 91% and 78%, respectively.

APIS; intra-model variability

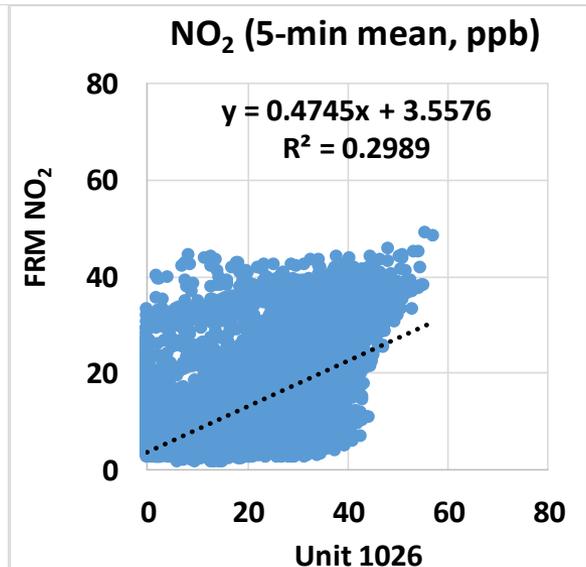
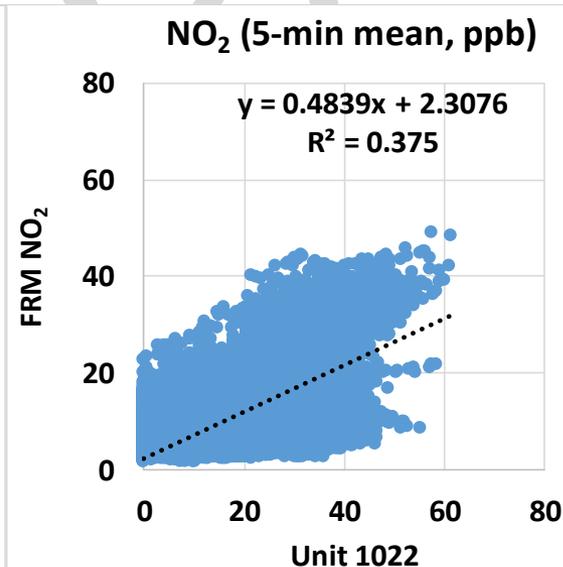
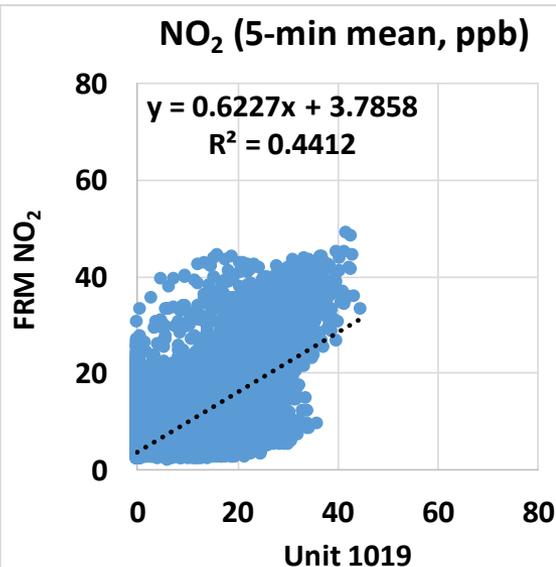
- Moderate measurement variability (42.1%) was observed between the three APIS units for NO₂ measurements



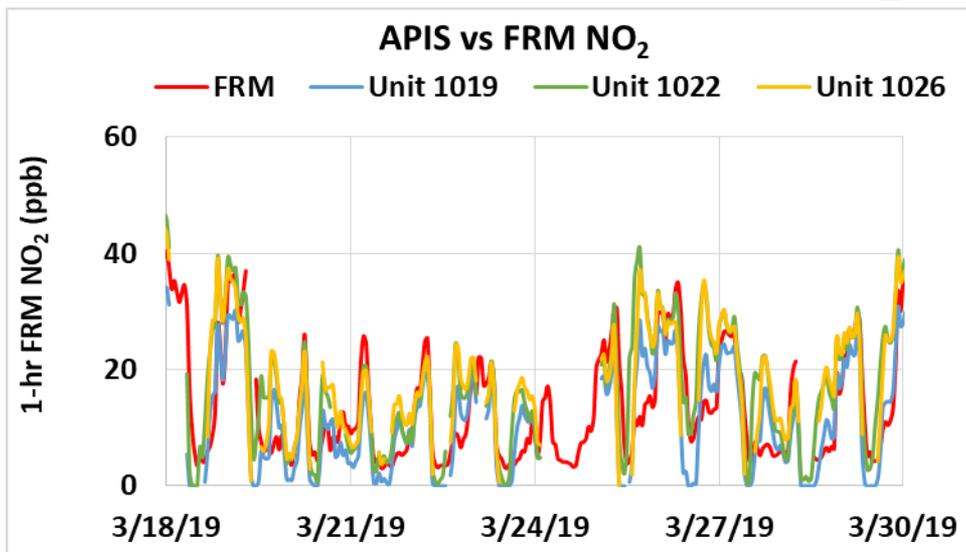
APIS vs FRM NO₂ (NO₂; 5-min mean)



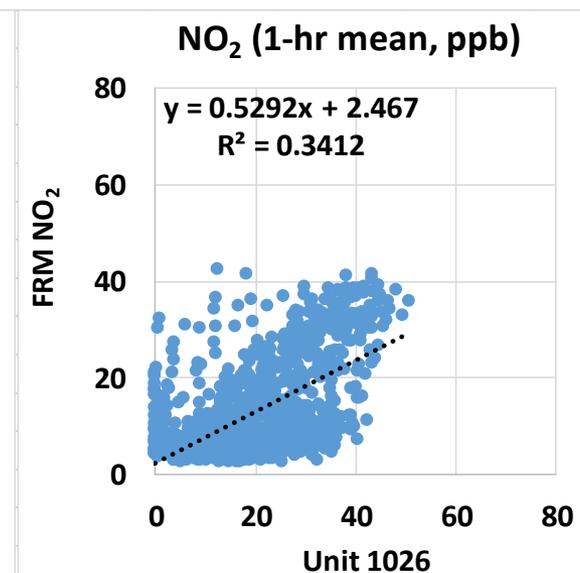
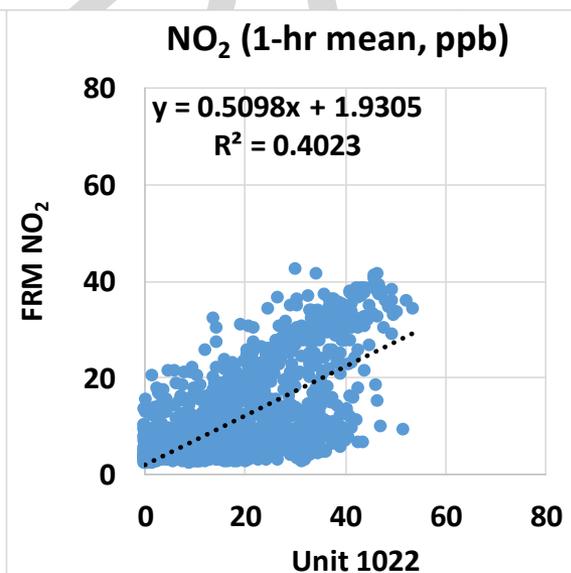
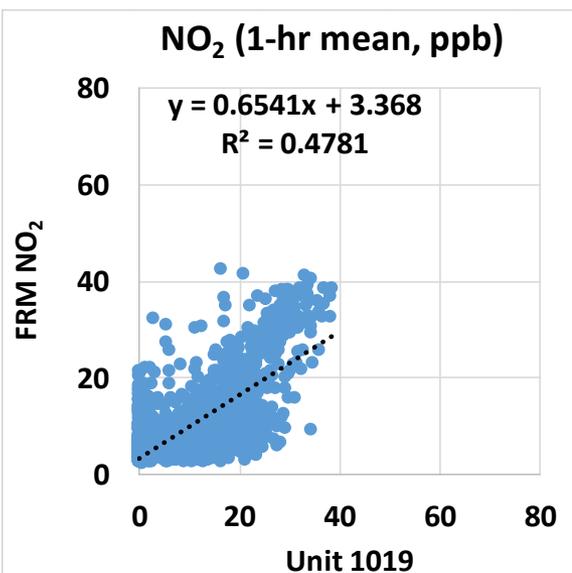
- APIS sensors showed weak correlations with the corresponding FRM NO₂ data ($R^2 \sim 0.37$)
- Overall, the APIS sensors overestimated NO₂ concentration as measured by the FRM instrument
- The APIS sensors seemed to track the NO₂ diurnal variations as recorded by the FRM instrument



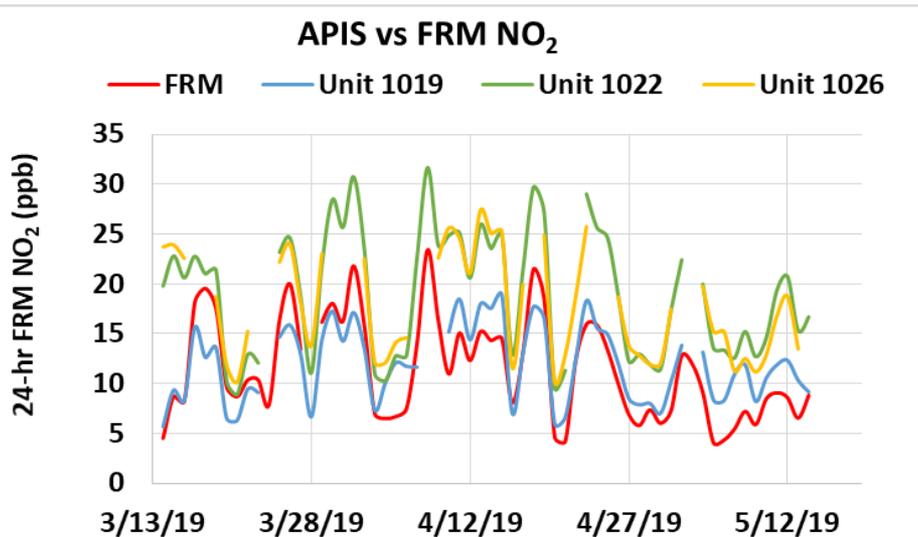
APIS vs FRM NO₂ (NO₂; 1-hr mean)



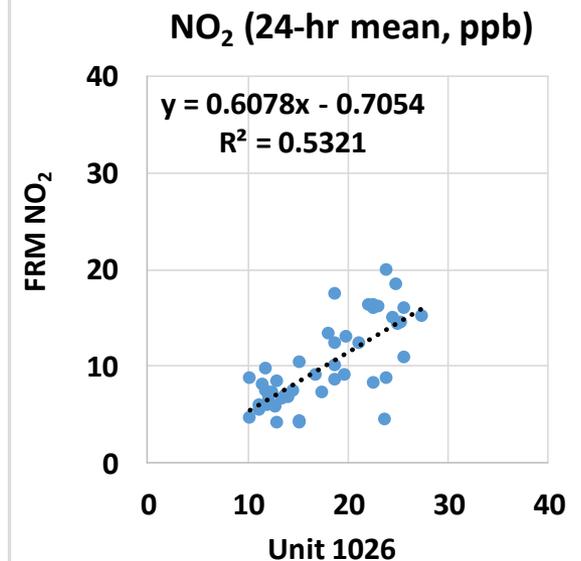
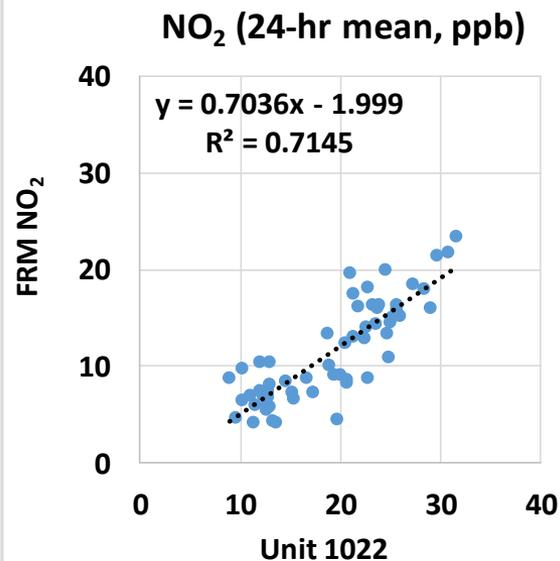
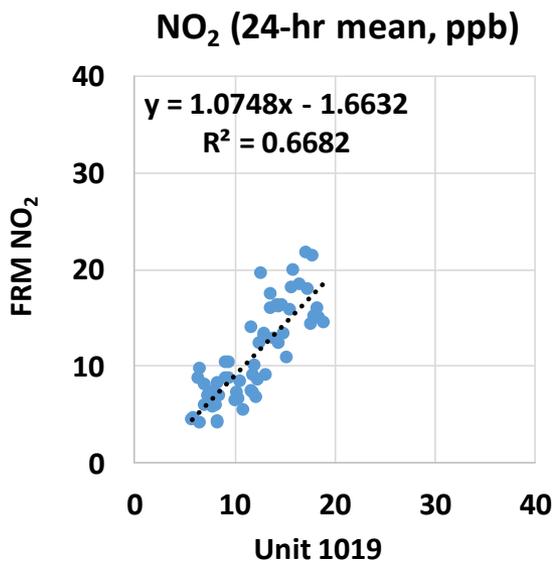
- APIS sensors showed weak correlations with the corresponding FRM NO₂ data ($R^2 \sim 0.41$)
- Overall, the APIS sensors overestimated NO₂ concentration as measured by the FRM instrument
- The APIS sensors seemed to track the NO₂ diurnal variations as recorded by the FRM instrument



APIS vs FRM NO₂ (NO₂; 24-hr mean)



- APIS sensors showed moderate correlations with the corresponding FRM NO₂ data ($R^2 \sim 0.64$)
- Overall, the APIS sensors overestimated NO₂ concentration as measured by the FRM instrument
- The APIS sensors seemed to track the NO₂ diurnal variations as recorded by the FRM instrument



Nitrogen Oxides (NO_x) in APIS

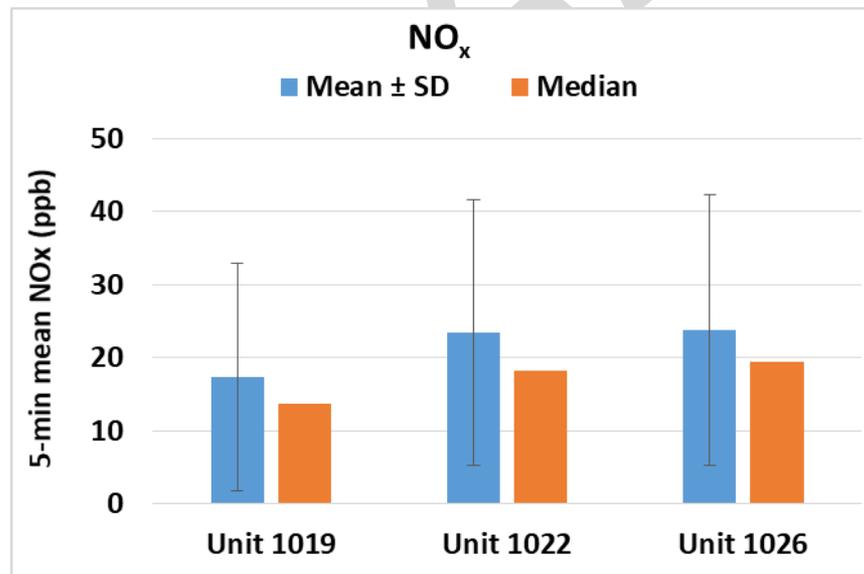
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Data validation & recovery

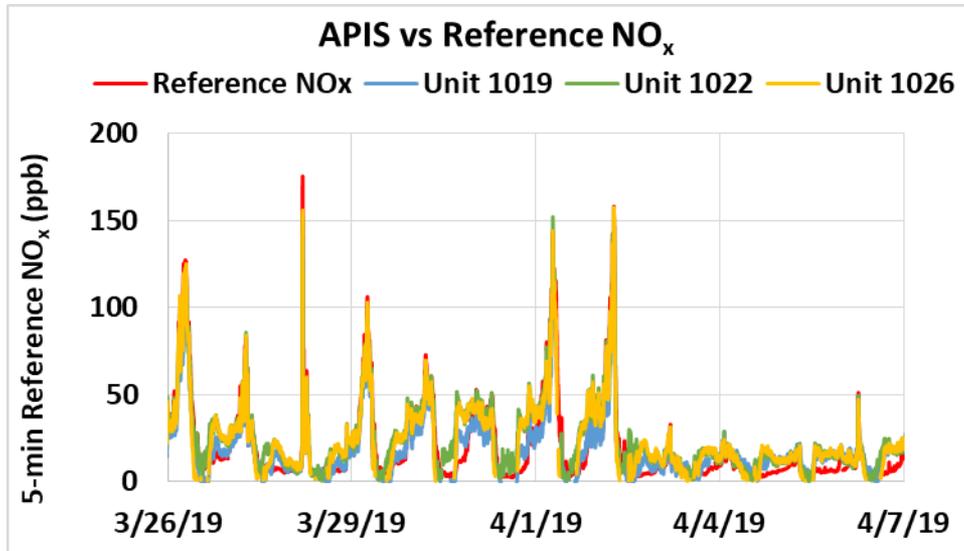
- Basic QA/QC procedures were used to validate the collected data (i.e. obvious outliers, negative values and invalid data-points were eliminated from the data-set)
- Data recovery from units 1019, 1022, and 1026 was 88%, 91% and 78%, respectively.

APIS; intra-model variability

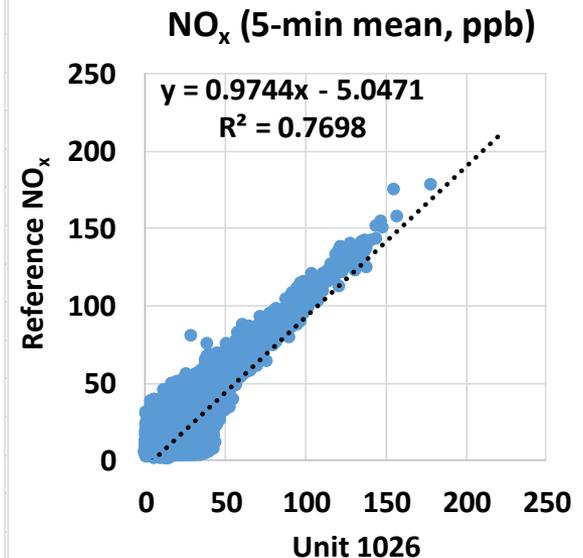
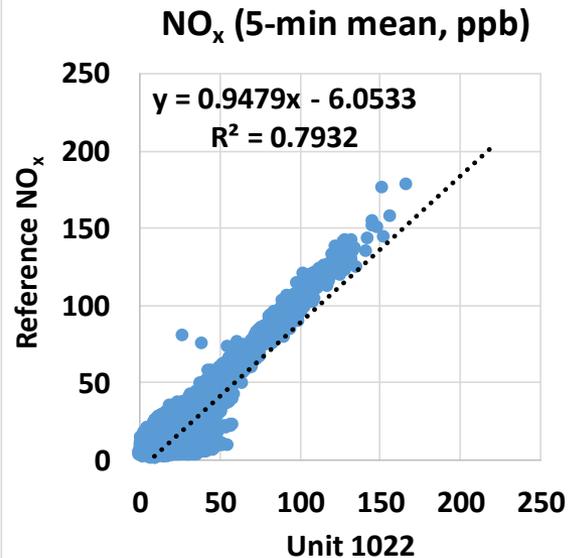
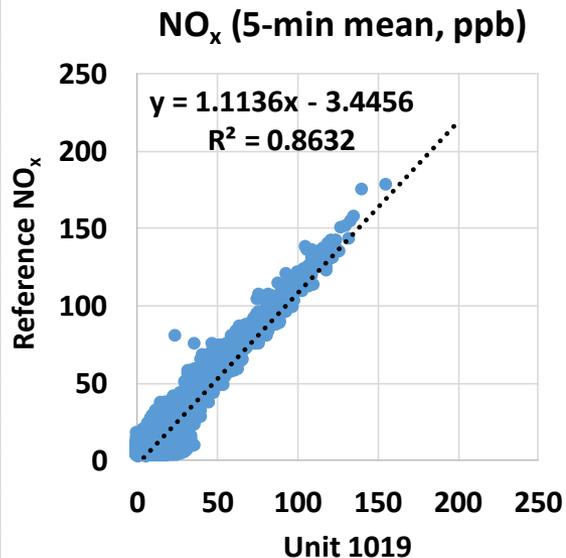
- Moderate measurement variability (30.1%) was observed between the three APIS units for NO_x measurements



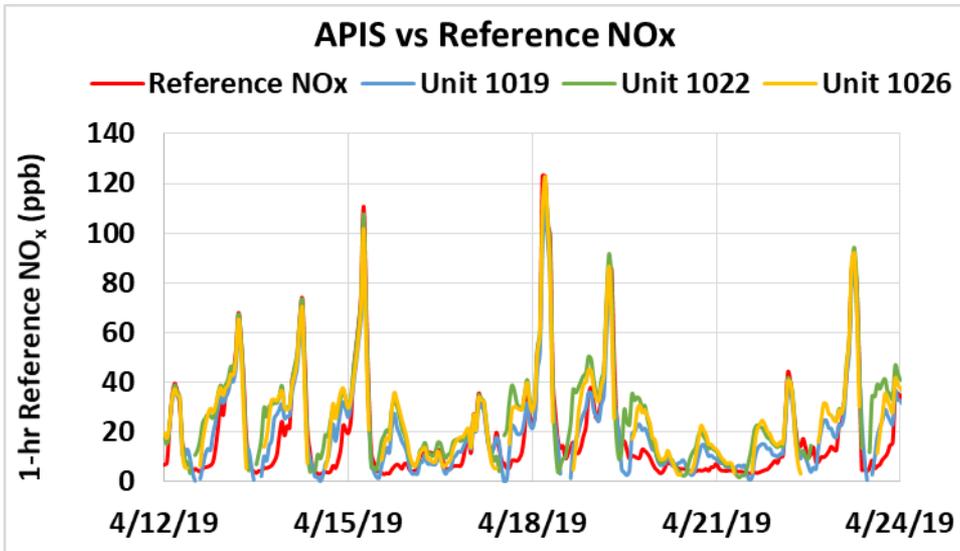
APIS vs Reference NO_x (NO_x; 5-min mean)



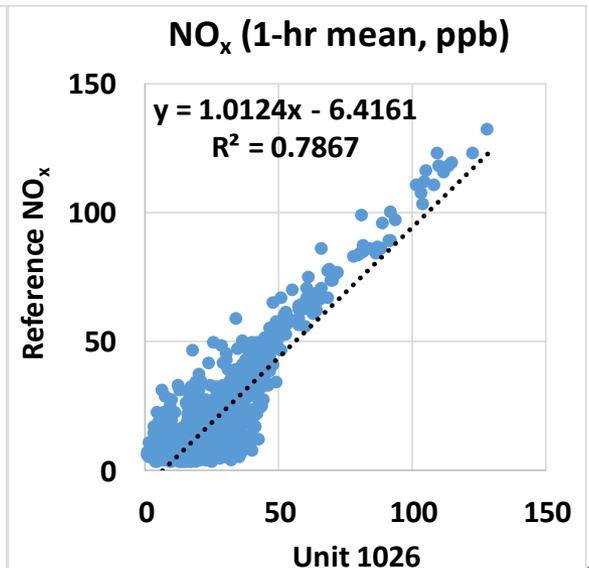
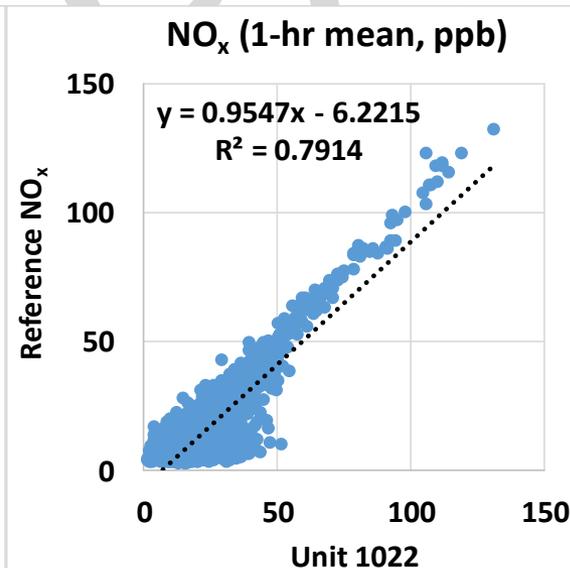
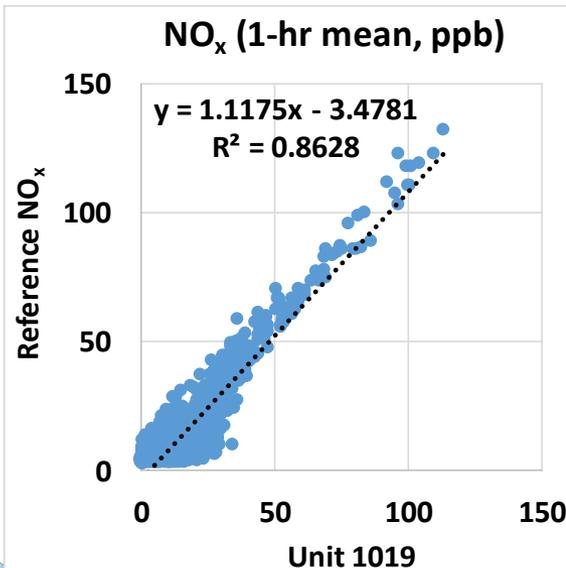
- APIS sensors showed strong correlations with the corresponding reference NO_x data ($R^2 \sim 0.81$)
- The APIS sensors seemed to track the NO_x diurnal variations as recorded by the reference instrument



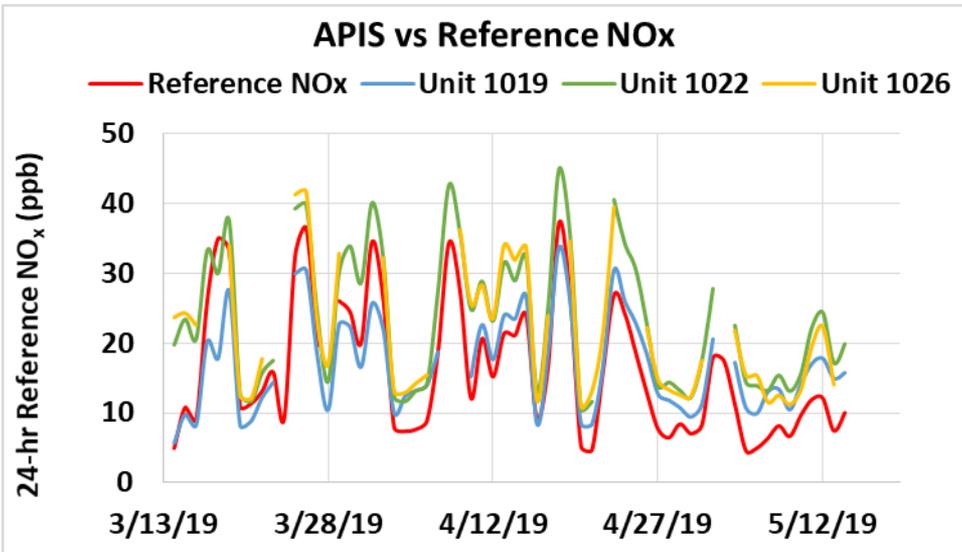
APIS vs Reference NO_x (NO_x; 1-hr mean)



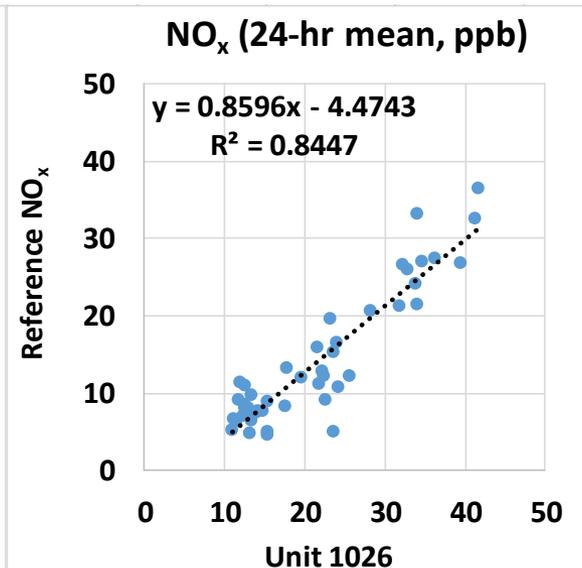
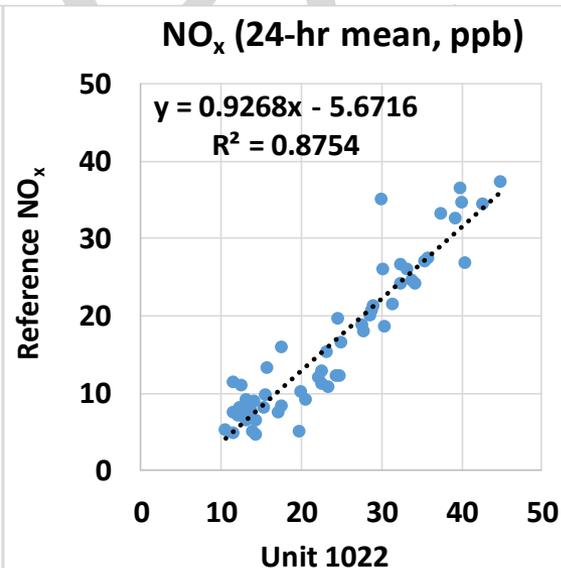
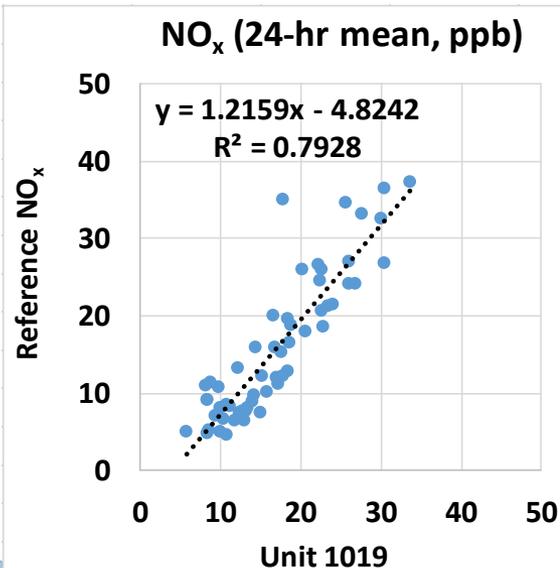
- APIS sensors showed strong correlations with the corresponding reference NO_x data ($R^2 \sim 0.81$)
- The APIS sensors seemed to track the NO_x diurnal variations as recorded by the reference instrument



APIS vs Reference NO_x (NO_x; 24-hr mean)



- APIS sensors showed strong correlations with the corresponding reference NO_x data ($R^2 \sim 0.84$)
- The APIS sensors seemed to track the NO_x diurnal variations as recorded by the reference instrument



Carbon Monoxide (CO) in APIS

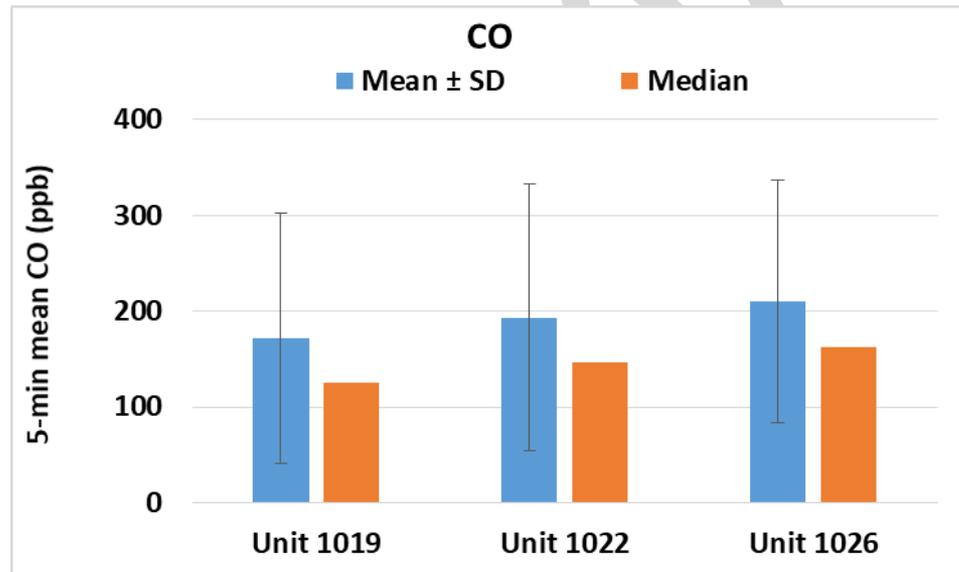
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Data validation & recovery

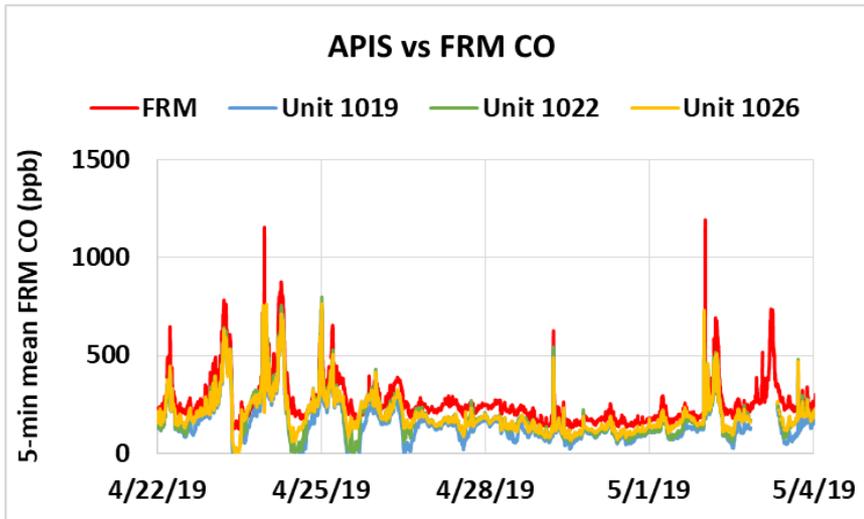
- Basic QA/QC procedures were used to validate the collected data (i.e. obvious outliers, negative values and invalid data-points were eliminated from the data-set)
- Data recovery from units 1019, 1022, and 1026 was 86%, 88% and 94%, respectively.

APIS; intra-model variability

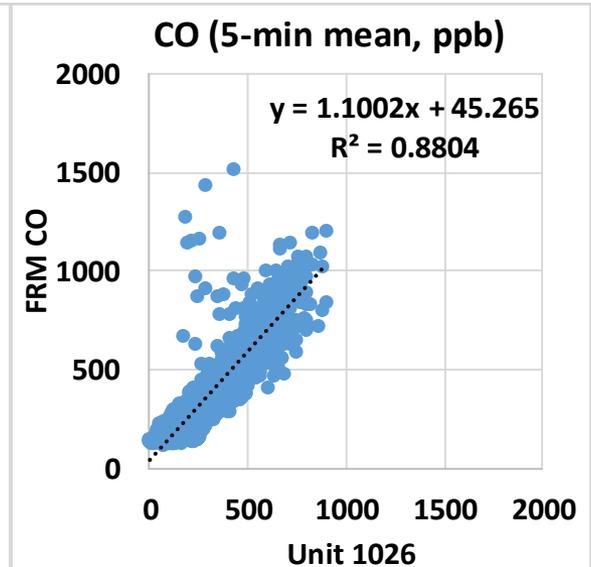
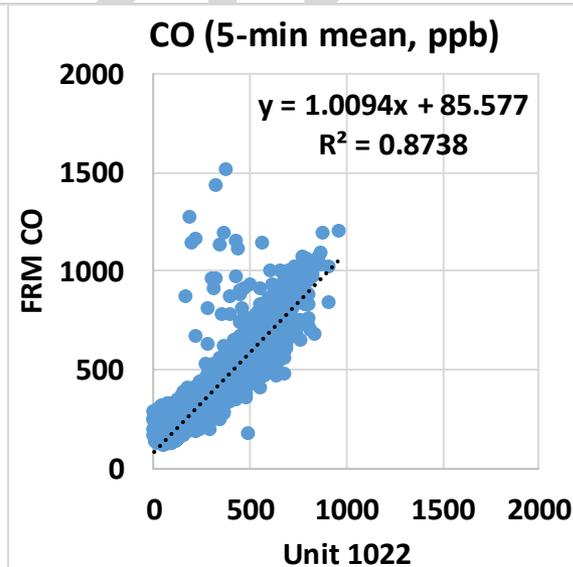
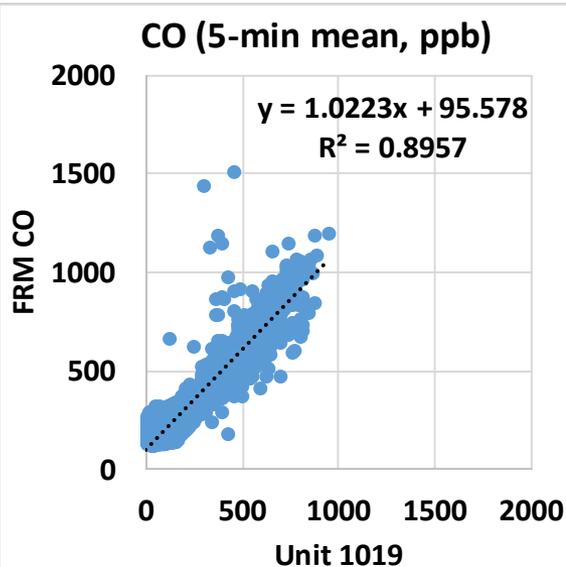
- Low measurement variability (19.8%) was observed between the three APIS units for CO measurements



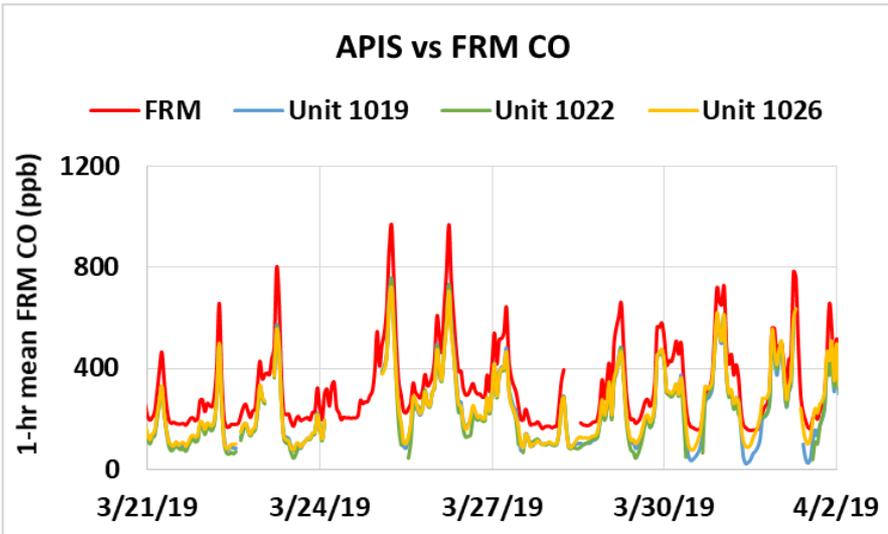
APIS vs FRM (CO; 5-min mean)



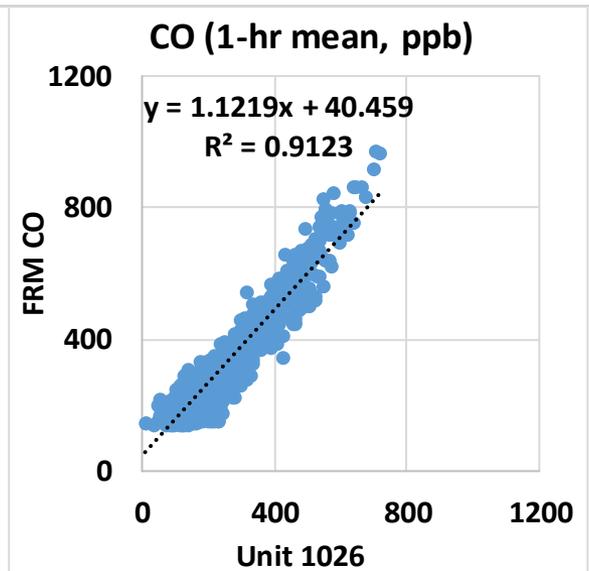
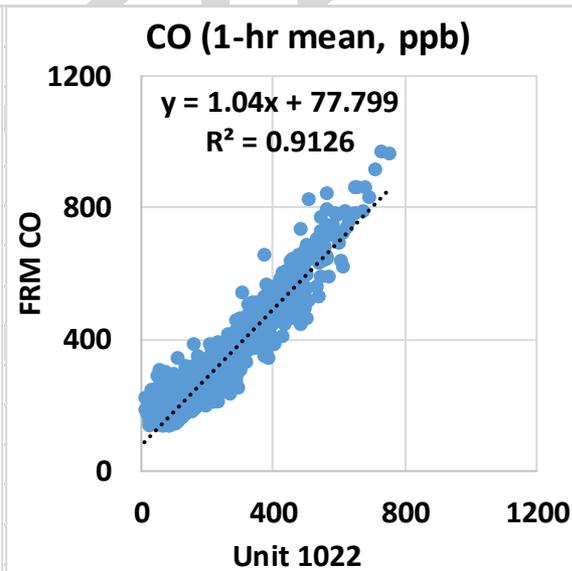
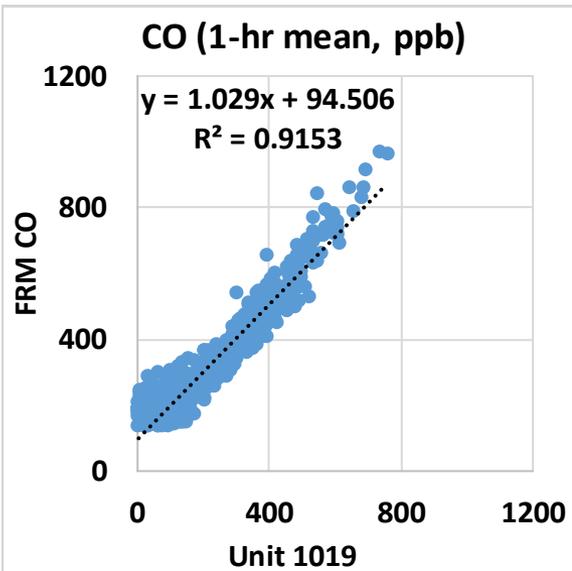
- APIS sensors showed strong correlations with the corresponding FRM CO data ($R^2 \sim 0.88$)
- Overall, the APIS sensors underestimated the CO concentration as measured by the FRM instrument
- The APIS sensors seemed to track the CO diurnal variations as recorded by the FRM instrument



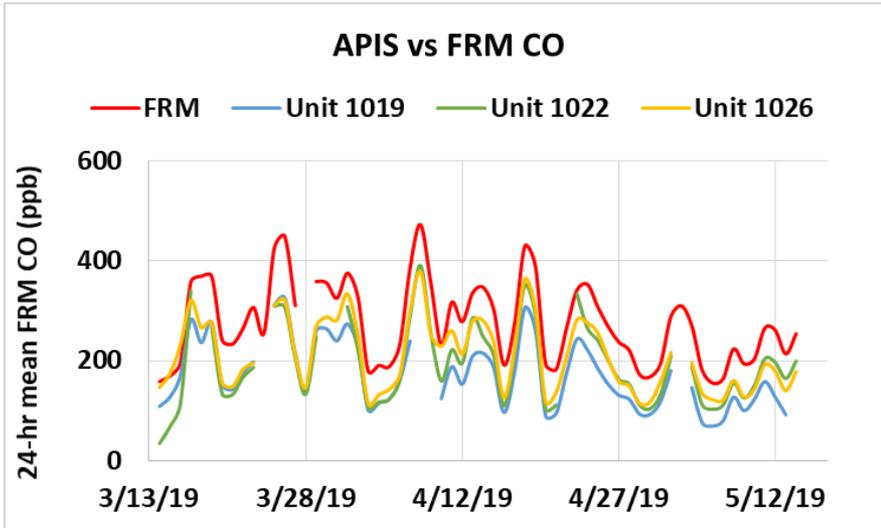
APIS vs FRM (CO; 1-hr mean)



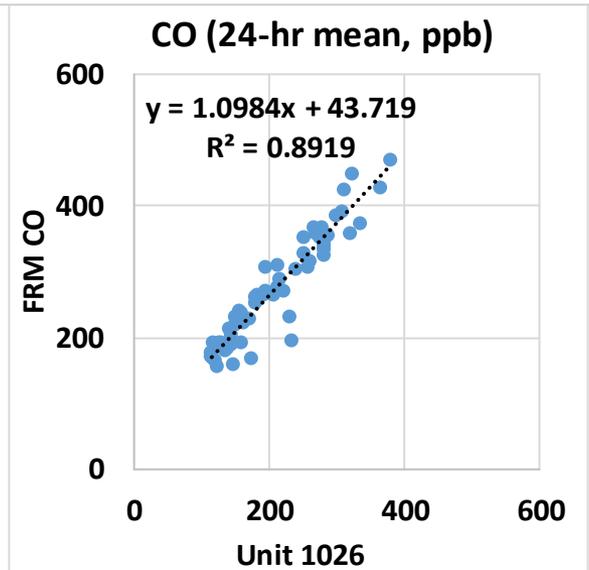
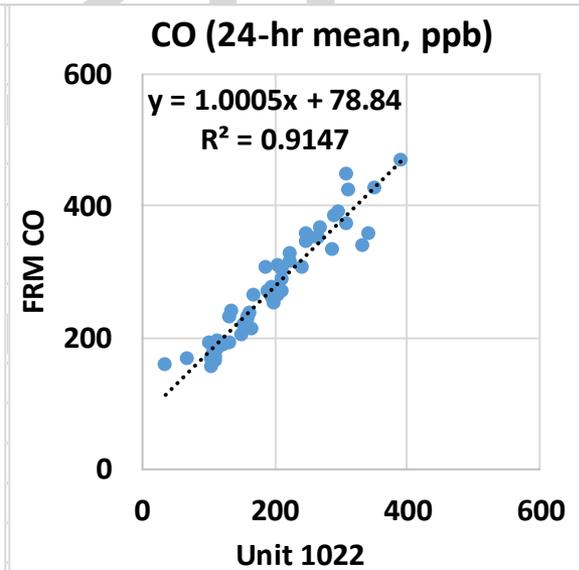
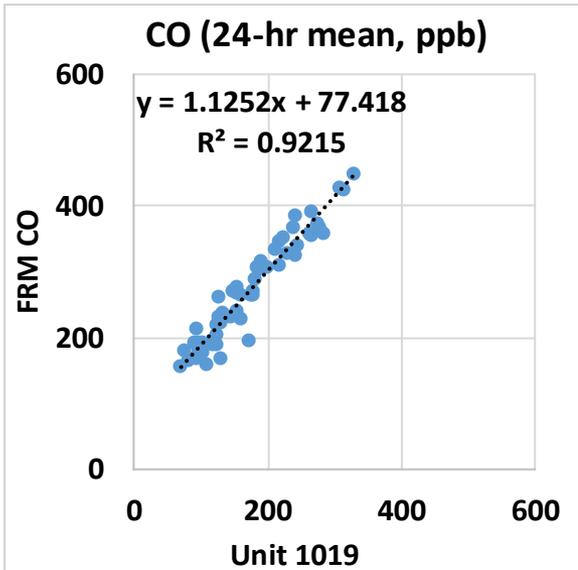
- APIS sensors showed very strong correlations with the corresponding FRM CO data ($R^2 \sim 0.91$)
- Overall, the APIS sensors underestimated the CO concentration as measured by the FRM instrument
- The APIS sensors seemed to track the CO diurnal variations as recorded by the FRM instrument



APIS vs FRM (CO; 24-hr mean)



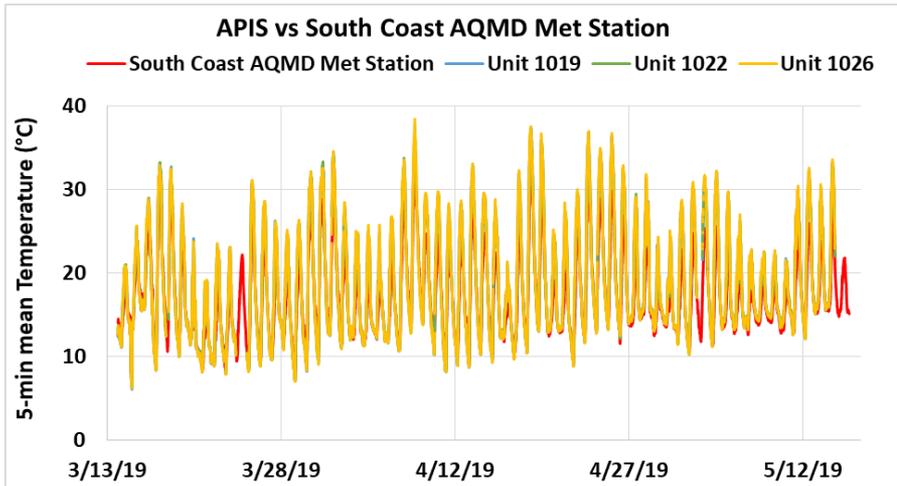
- APIS sensors showed very strong correlations with the corresponding FRM CO data ($R^2 \sim 0.91$)
- Overall, the APIS sensors underestimated the CO concentration as measured by the FRM instrument
- The APIS sensors seemed to track the CO diurnal variations as recorded by the FRM instrument



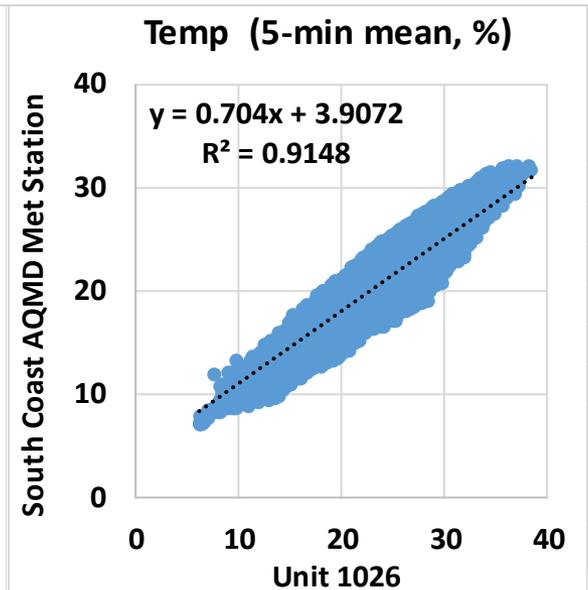
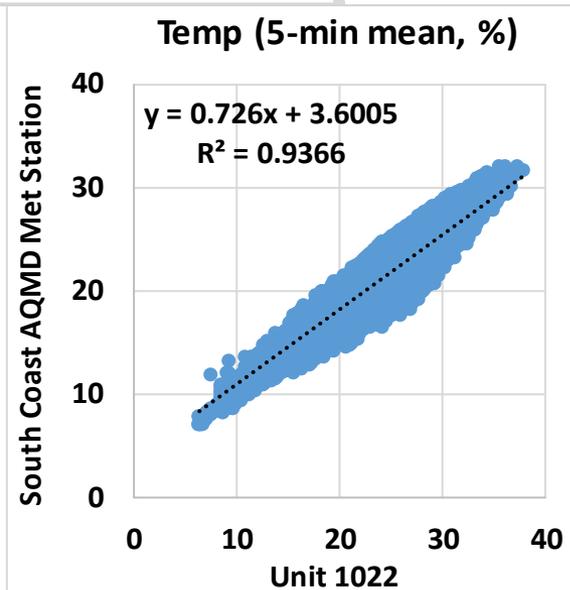
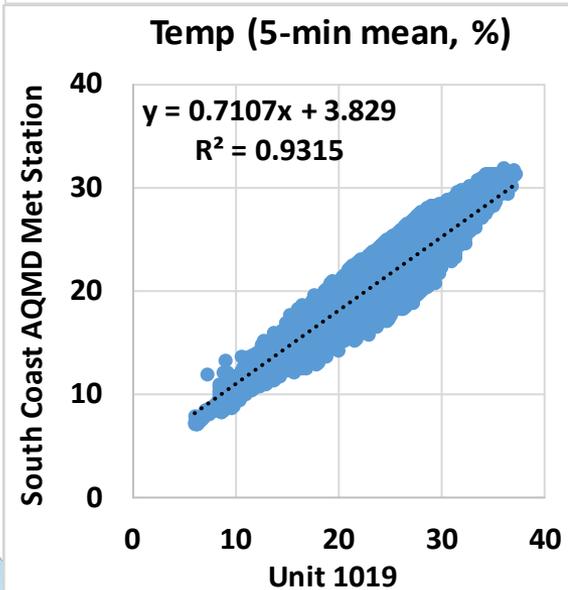
Meteorological data in APIS

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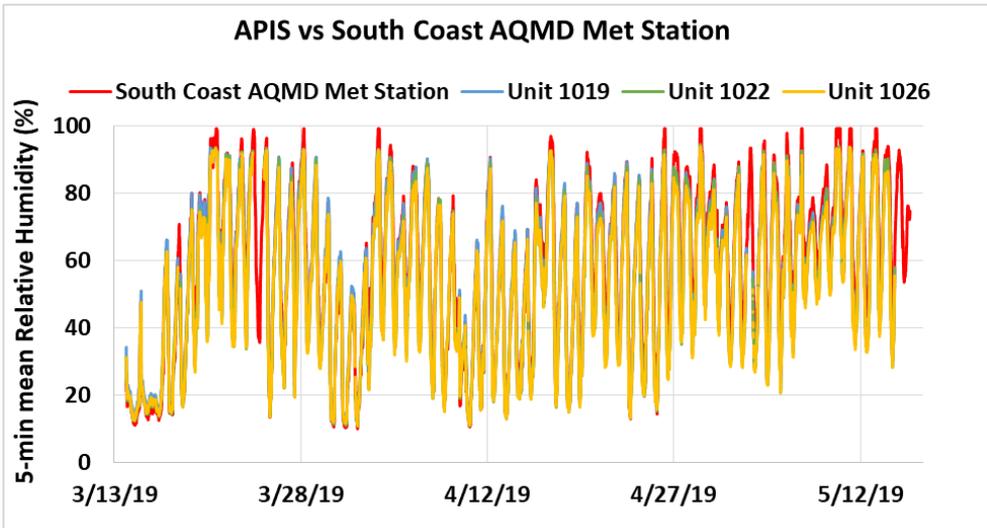
APIS vs South Coast AQMD Met Station (Temp; 5-min mean)



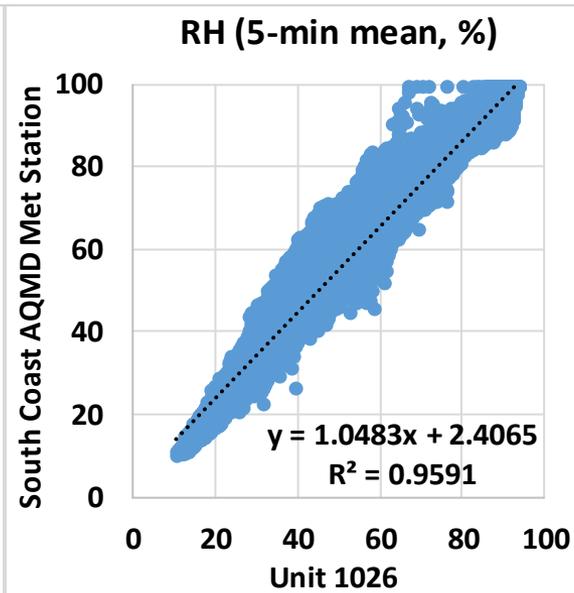
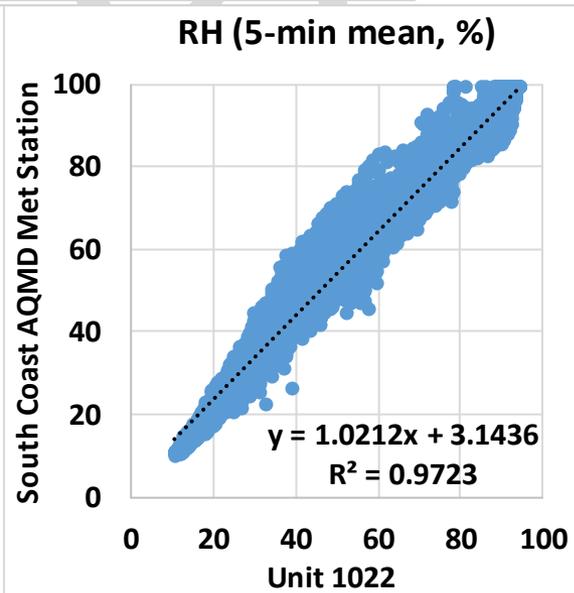
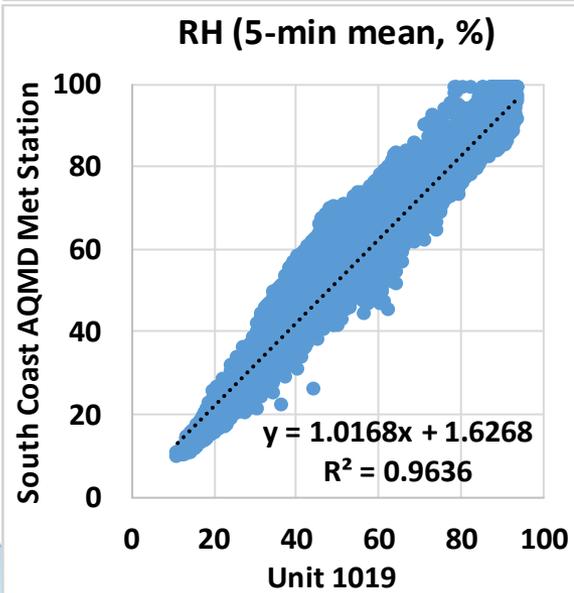
- The APIS temperature measurements showed very strong correlations with the corresponding South Coast AQMD Met Station data ($R^2 \sim 0.93$)
- Overall, the APIS temperature measurements overestimated the corresponding South Coast AQMD Met Station data
- The APIS sensors seemed to track well the temperature diurnal variations as recorded by South Coast AQMD Met Station



APIS vs South Coast AQMD Met Station (RH; 5-min mean)



- The APIS RH measurements showed very strong correlations with the corresponding South Coast AQMD Met Station data ($R^2 \sim 0.96$)
- Overall, the APIS temperature measurements underestimated the corresponding South Coast AQMD Met Station data
- The APIS sensors seemed to track well the RH diurnal variations as recorded by South Coast AQMD Met Station



Discussion

- The three **APIS** sensors' data recovery from all units was ~ 81%, ~ 86% and ~ 89% for ozone, NO_x and CO, respectively
- The three sensors showed low to moderate intra-model variability (~13% to 42%) for ozone, NO_x and CO measurements.
- During the field deployment testing period:
 - Ozone sensors showed strong correlations ($R^2 \sim 0.77$, 5-min mean) with the FEM instrument and overestimated the corresponding FEM Ozone measurements
 - Nitrogen monoxide (NO) sensors showed very strong correlations ($R^2 \sim 0.93$, 5-min mean) with the reference instrument
 - NO₂ sensors showed weak correlations ($R^2 \sim 0.37$, 5-min mean) with the reference instrument and overestimated the corresponding FRM NO₂ data
 - NO_x sensors showed strong correlations ($R^2 \sim 0.81$, 5-min mean) with the reference instrument
 - CO sensors showed strong correlations ($R^2 \sim 0.88$, 5-min mean) with the FRM instrument and underestimated the corresponding FRM CO data
- 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