Field Evaluation of Perkin Elmer - ELM

South Coast AQMD

AQ-SPEC
Air Quality Sensor Performance Evaluation Center

Background

- From 07/22/2015 to 09/25/2015, three Perkin Elmer ELM monitors were deployed in Rubidoux and run side-by-side SCAQMD's Federal Reference Method (FRM) and Federal Equivalent Method (FEM) instruments measuring the same pollutants

- ELM (*3 units tested*):
  - Metal-Oxide gas sensors (non-FRM)
  - Light-Scattering PM sensors (non-FEM)
  - Each unit measures: NO, NO_2, O_3, PM10, Temp and RH
  - Unit cost: ~$5,200
  - Time resolution: 1-min
  - Units IDs: 1088, 1177, 1197

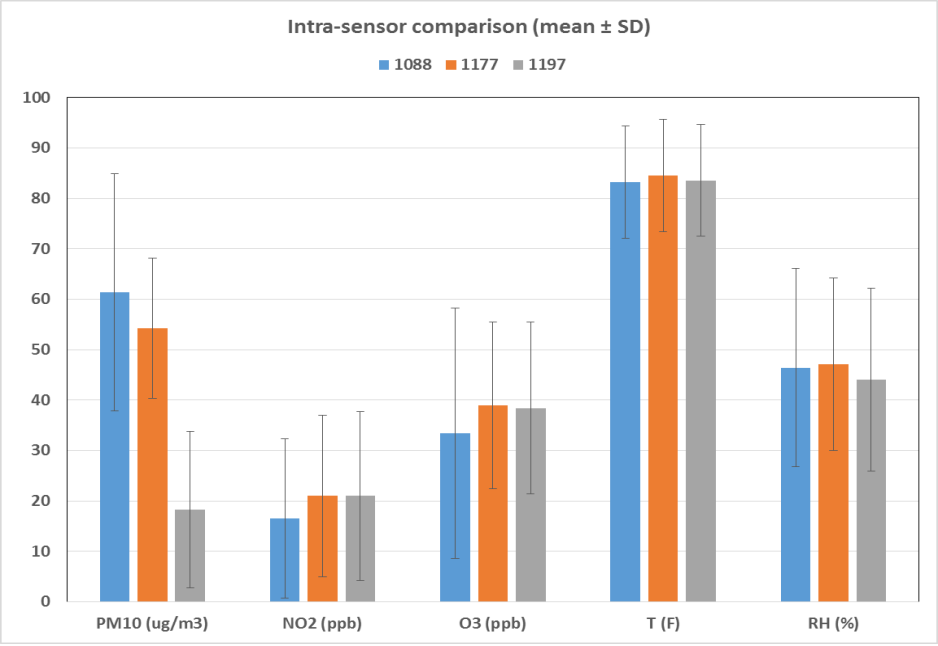
- SCAQMD FRM/FEM instruments:
  - NO_X instrument; cost: ~$11,000
    - Time resolution: 1-min
  - O_3 instrument; cost: ~$13,000
    - Time resolution; 1-min
  - Meteorological station (wind speed, wind direction temperature, relative humidity, and pressure); cost: ~$5,000
    - Time resolution: 1-min
  - MetOne BAM (reference method); Cost: ~$20,000
    - Beta-attenuation monitor (FEM); Measures $PM_{2.5}$
    - Time resolution: 1-hr
  - GRIMM (reference method); Cost: ~$25,000 and up
    - Optical particle counter (FEM); Uses proprietary algorithms to calculate total PM, $PM_{2.5}$, and PM_1 from particle number measurements
    - Time resolution: 1-min

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 all three ELM sensors was ~100%

ELM; intra-model variability

- With the exception of PM_{10}, modest-to-low intra-model variability was observed for all measured pollutants and meteorological variables

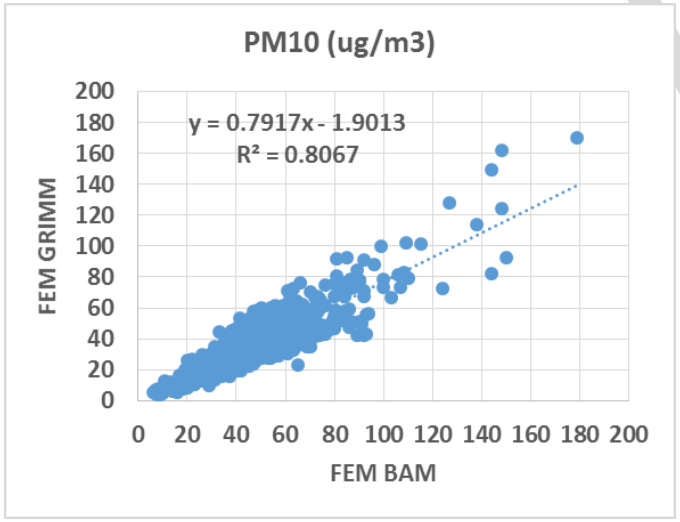


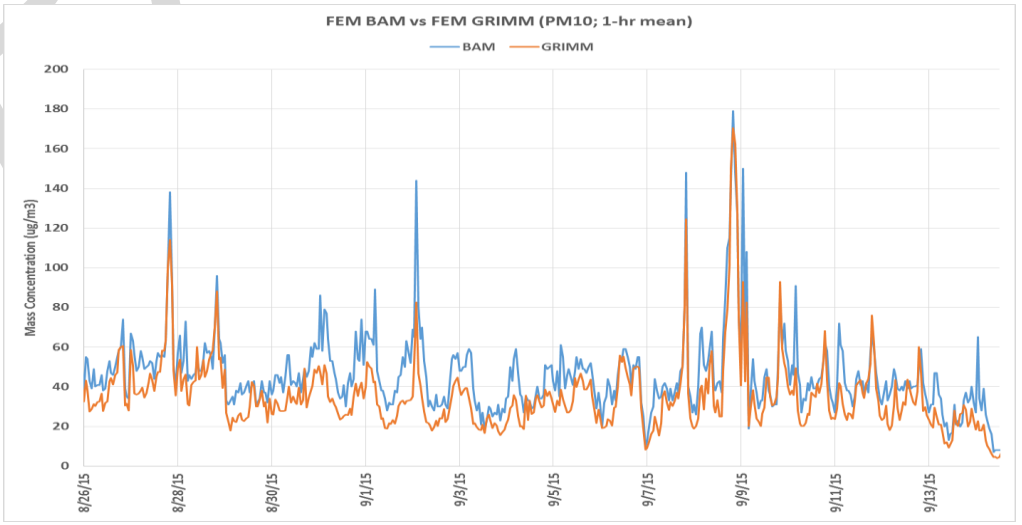
Data validation & recovery

- 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_{10} data recovery for the GRIMM and BAM instruments was ~100%

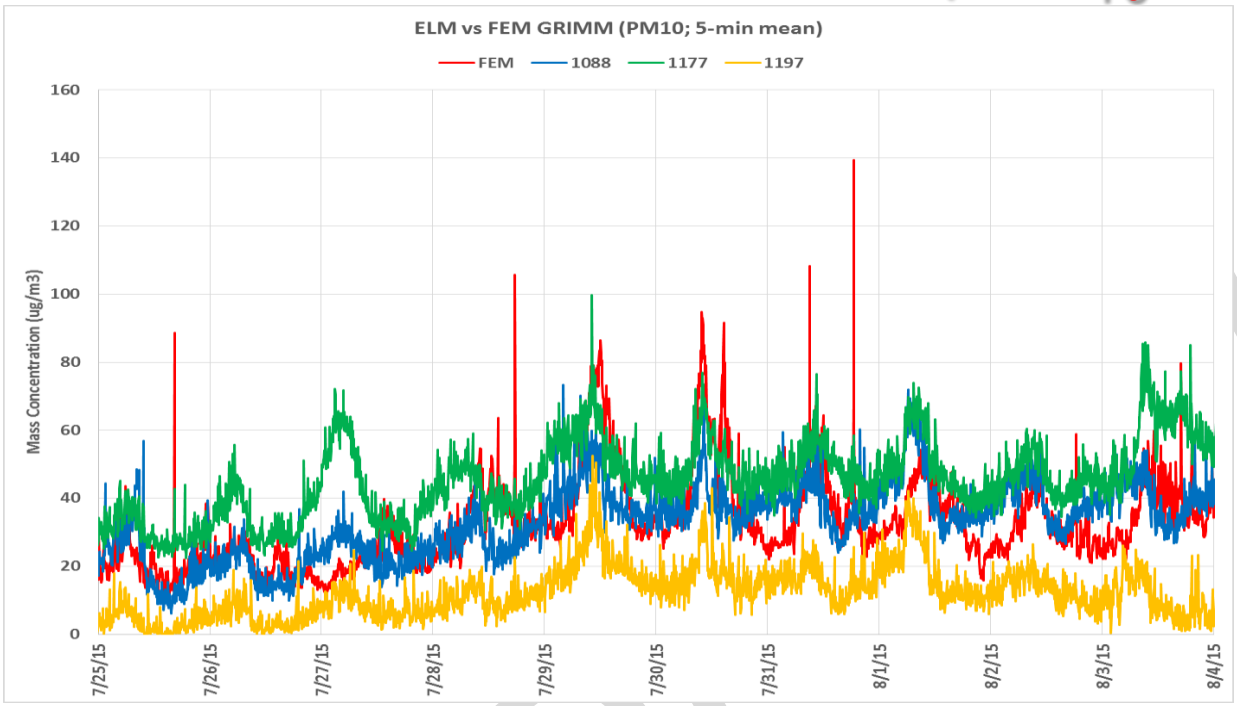
Equivalent Methods; BAM vs GRIMM

- Very good correlation between the two equivalent methods $R^2 = 0.81$

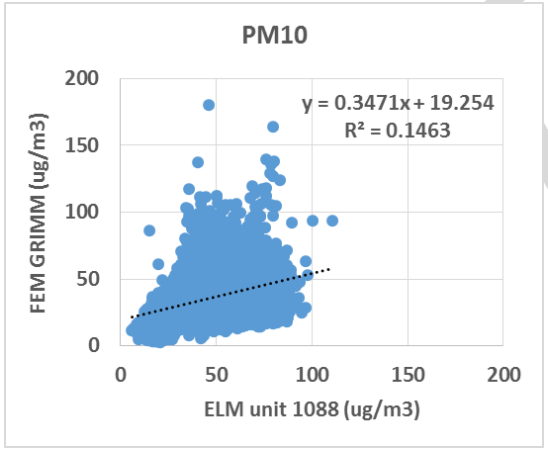


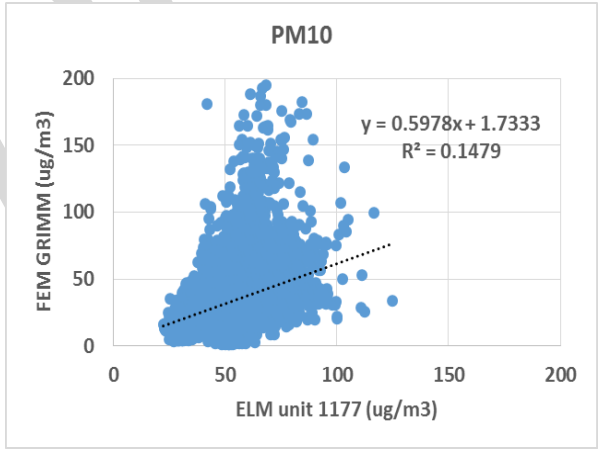


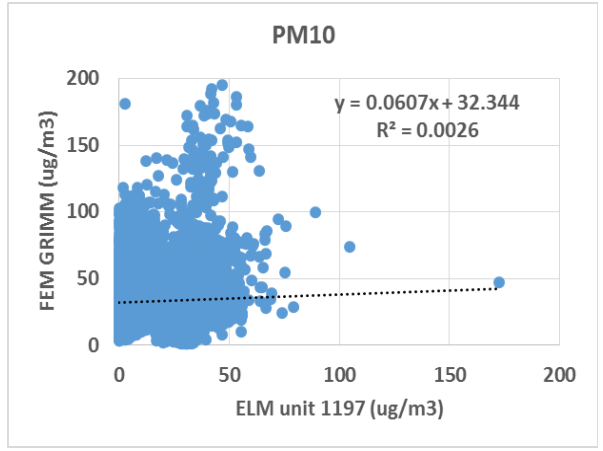
ELM vs FEM GRIMM (PM_{10}; 5-min mean)



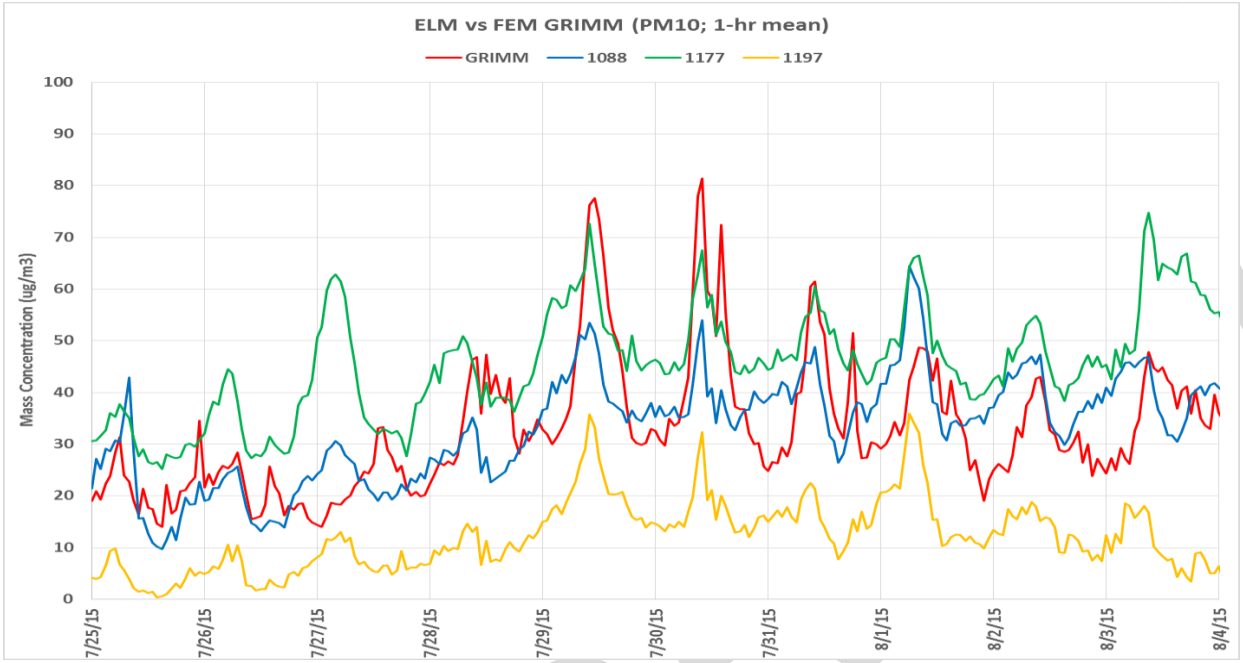
- ELM PM_{10} measurements do not seem to track well the PM10 diurnal variations recorded by the GRIMM (FEM) instrument
- All ELM units show very poor correlation with the corresponding FEM data (R^2<0.15)



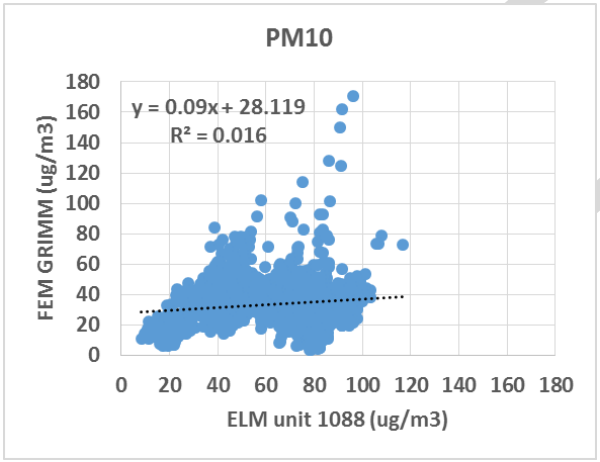


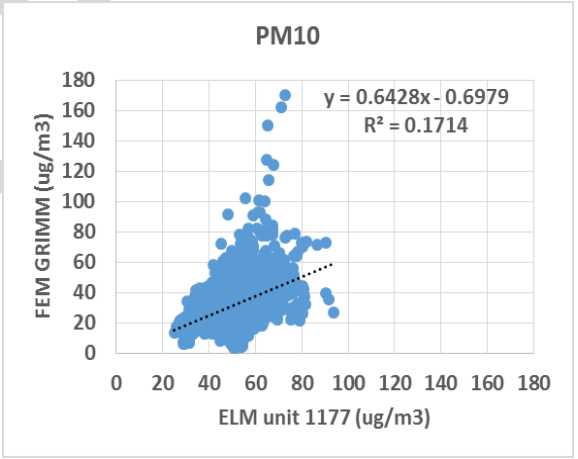


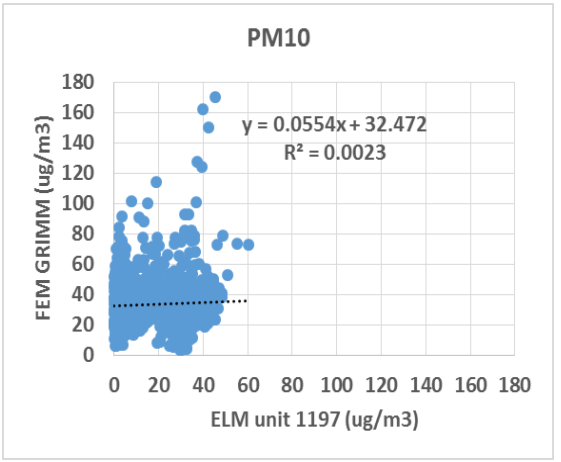
ELM vs FEM GRIMM (PM_{10}; 1-hr mean)



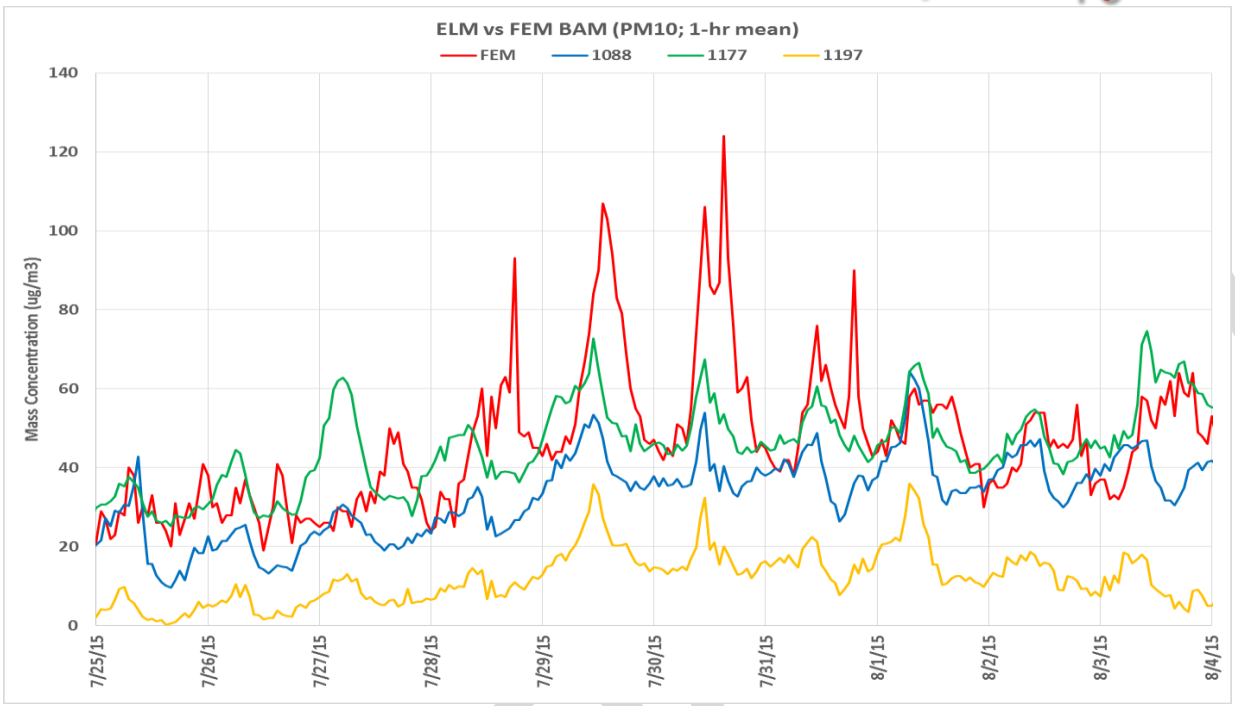
- ELM PM_{10} measurements do not seem to track well the PM10 diurnal variations recorded by the GRIMM (FEM) instrument
- All ELM units show very poor correlation with the corresponding FEM data (R^2<0.17)



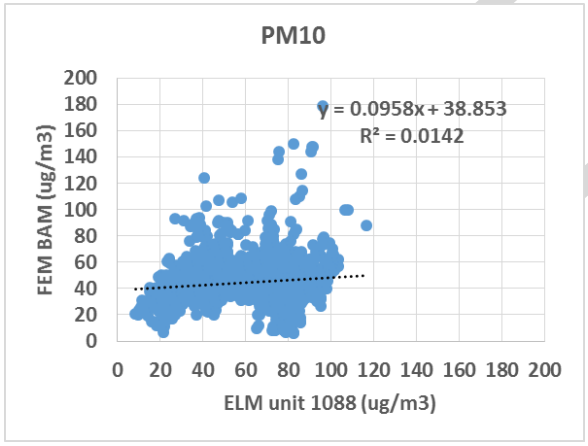


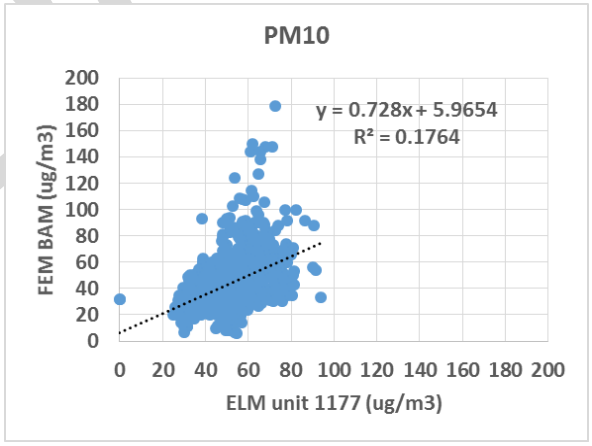


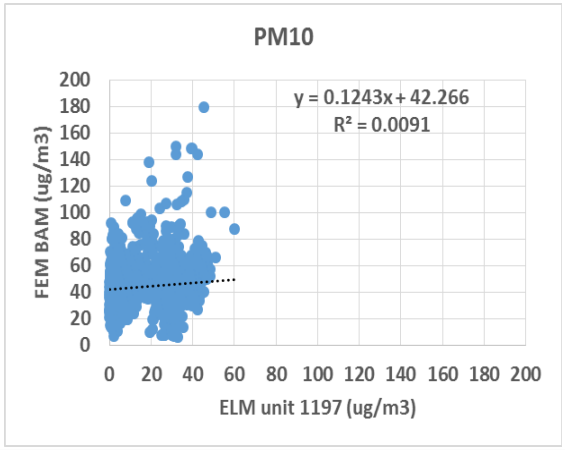
ELM vs FEM BAM (PM_{10}; 1-hr mean)



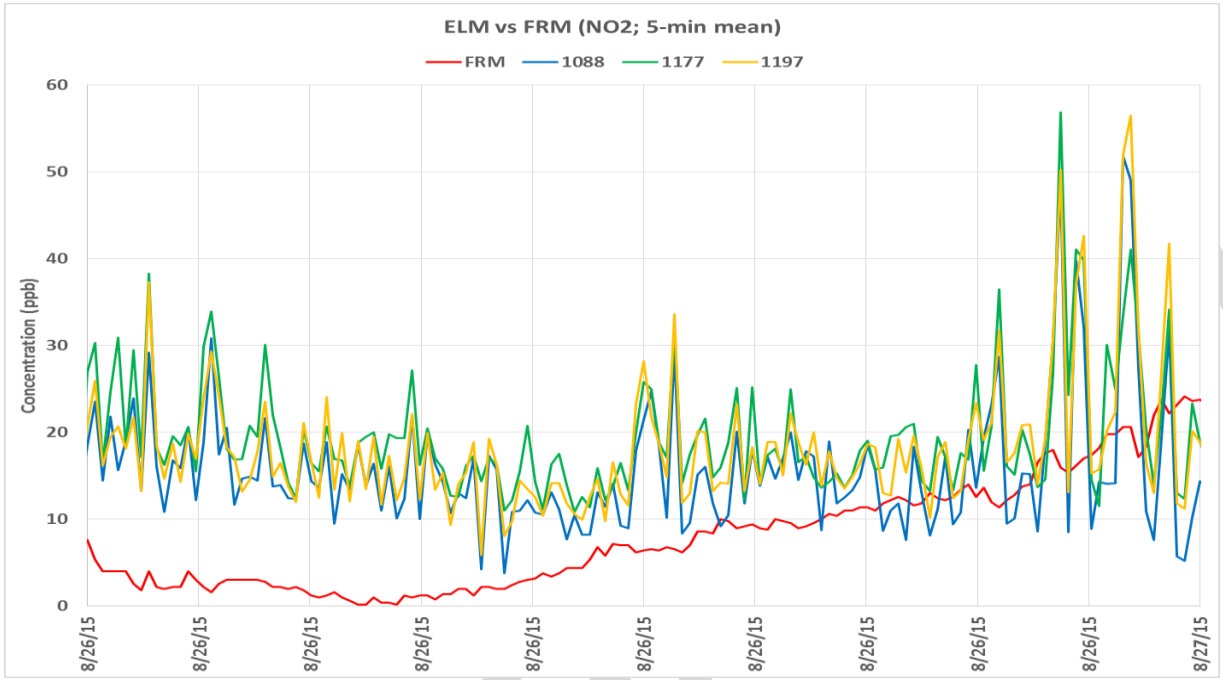
- ELM PM_{10} measurements do not seem to track well the PM10 diurnal variations recorded by the BAM (FEM) instrument
- All ELM units show very poor correlation with the corresponding FEM data (R^2<0.18)



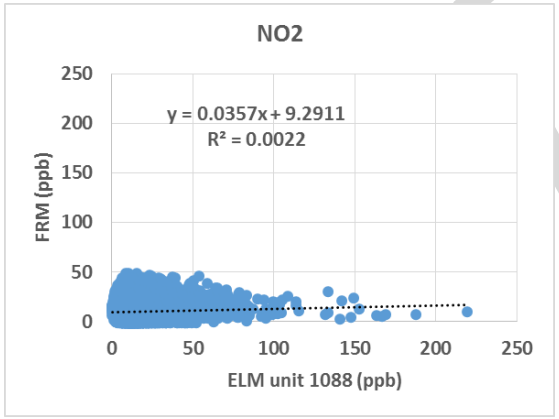


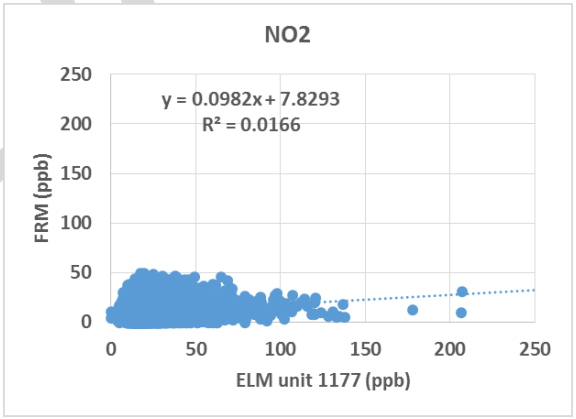


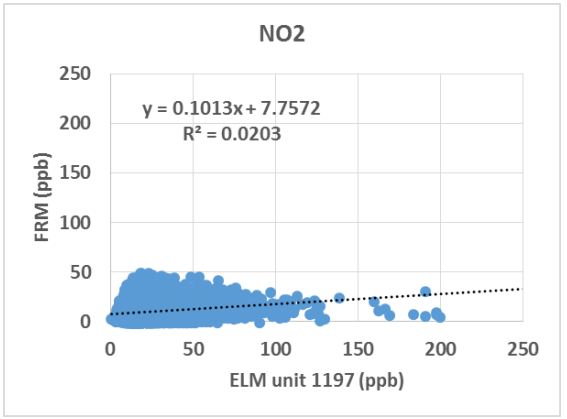
ELM vs FRM (NO_2; 5-min mean)



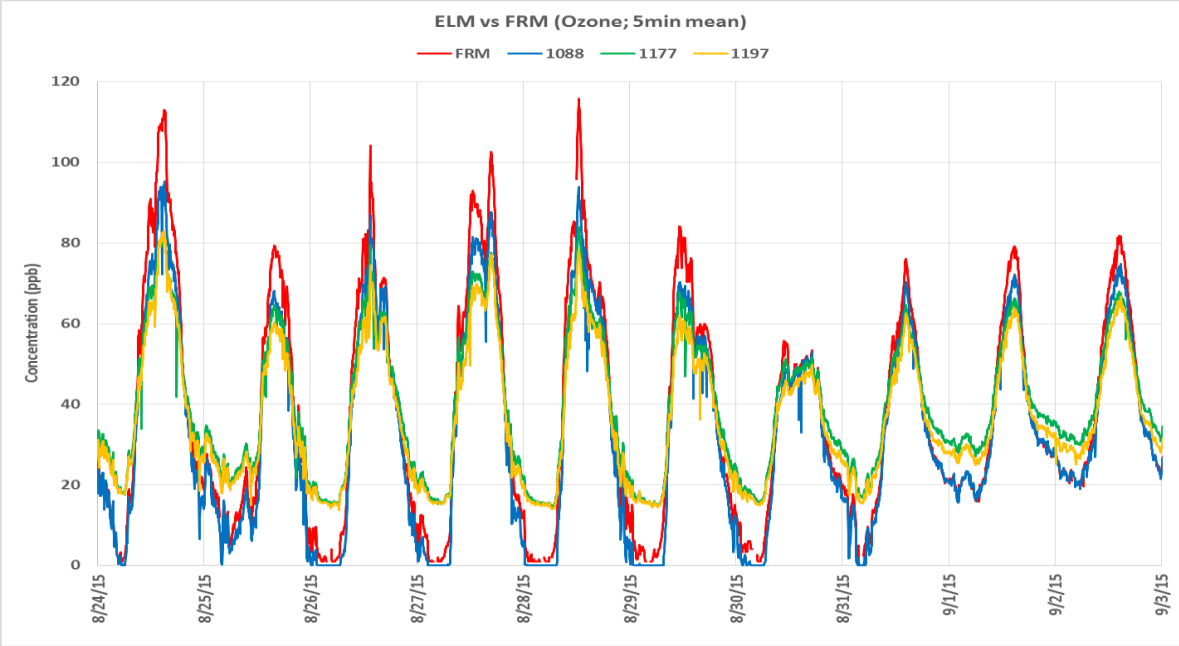
- ELM NO_2 measurements do not seem to track the NO_2 diurnal variations recorded by the FRM instrument
- Very poor correlation with FRM measurement data (R^2~0.0)
- Potential interference w/ ambient ozone and/or RH (to be investigated during chamber experiments)



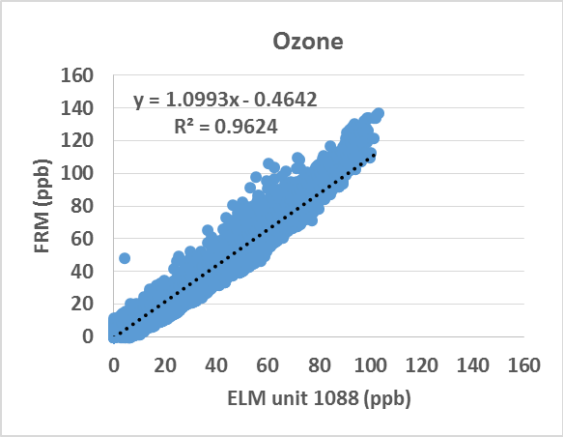


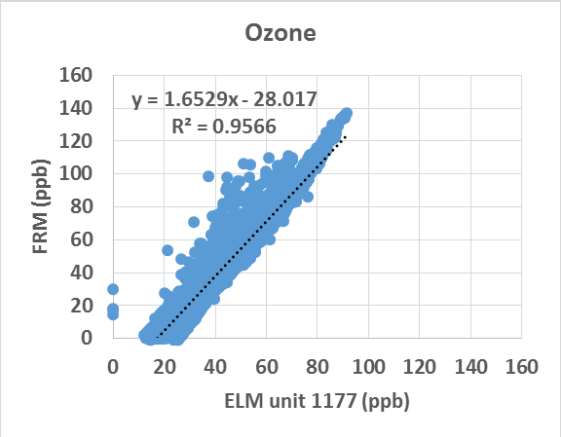


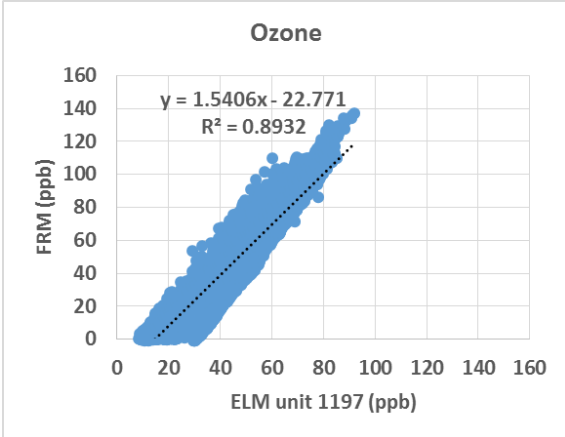
ELM vs FRM (O_3; 5-min mean)



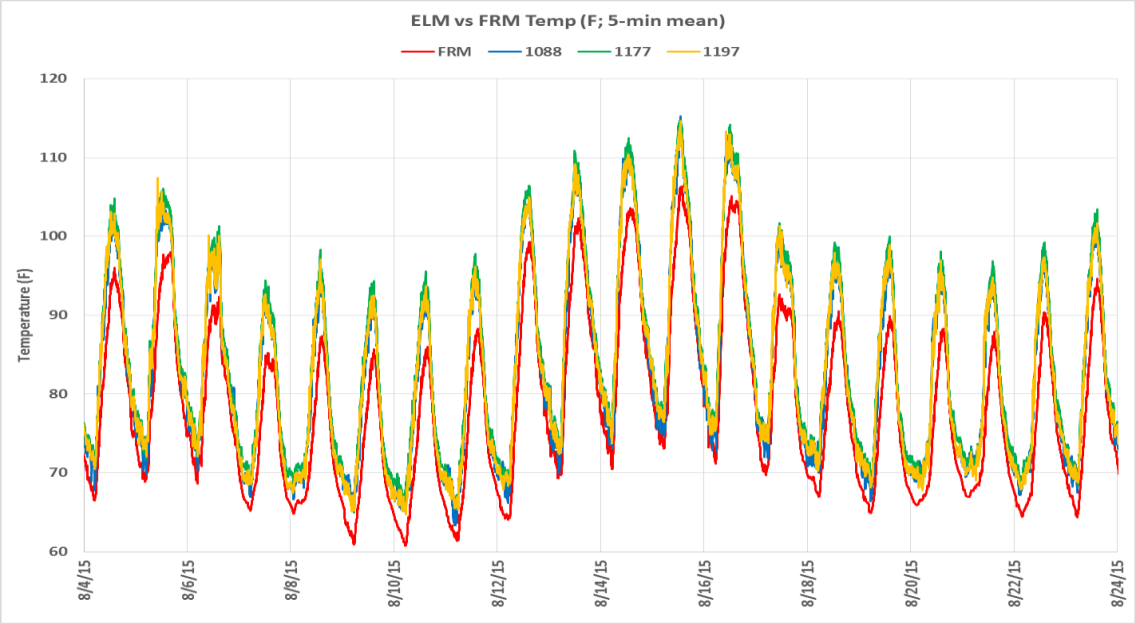
- ELM Ozone measurements correlate very well with the corresponding FRM measurements (0.89< R^2<0.96)
- For units 1177 and 1199 the baseline is substantially higher than 0



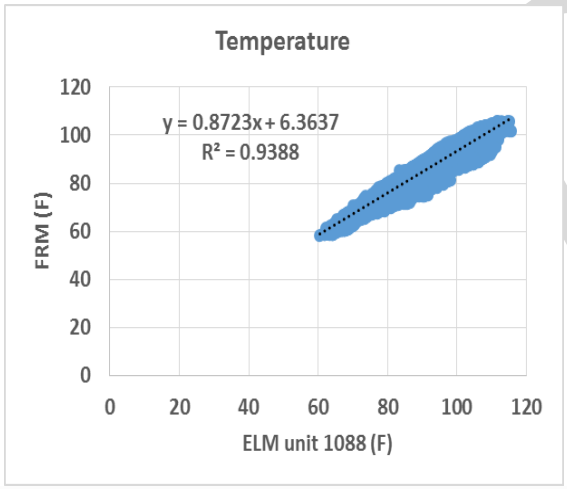


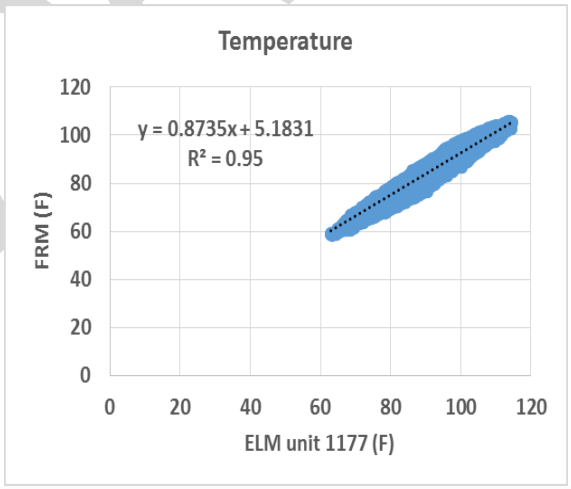


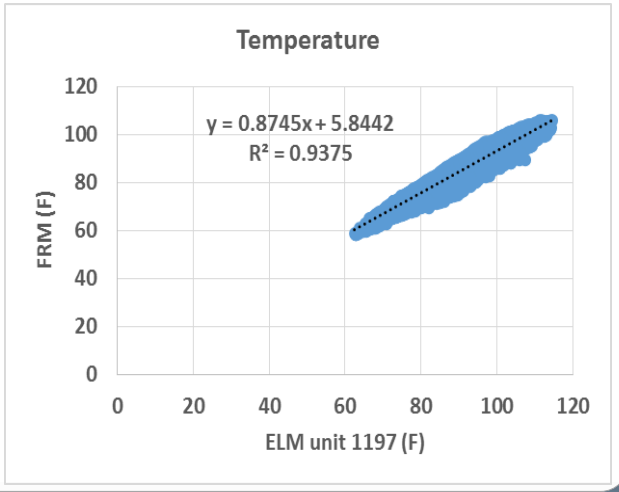
Temperature (5-min mean)



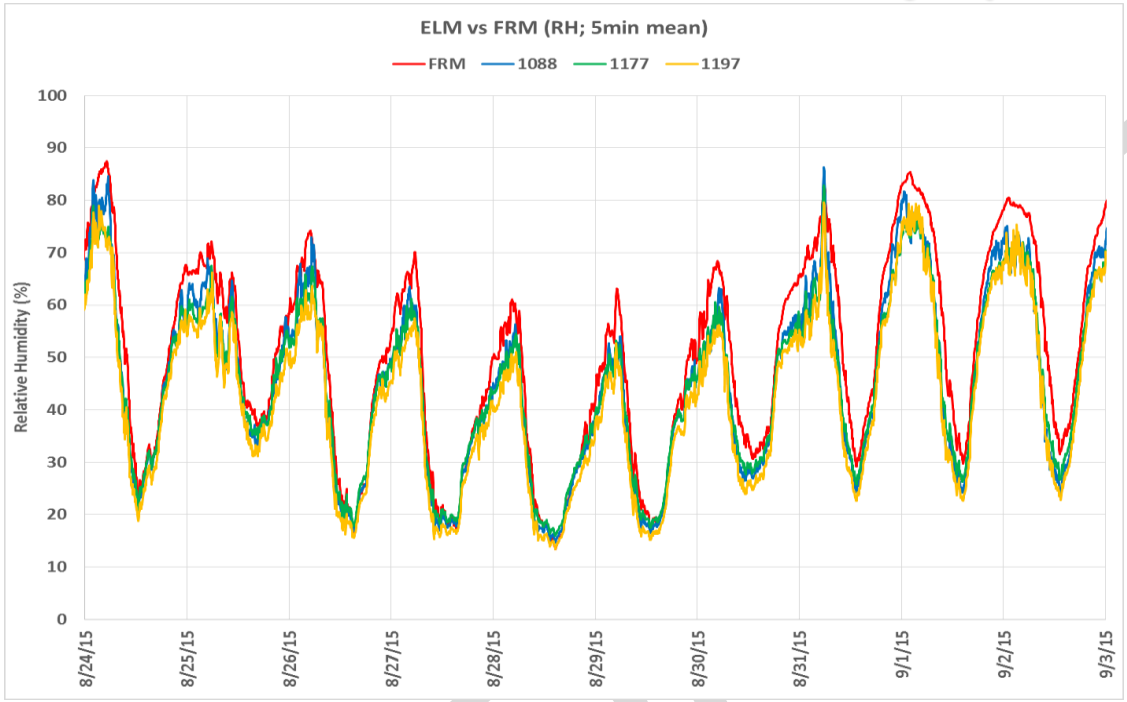
- ELM Temp measurements show excellent correlation with the corresponding Station temp data ($0.94 < R^2 < 0.95$)
- ELM temp data are slightly overestimated



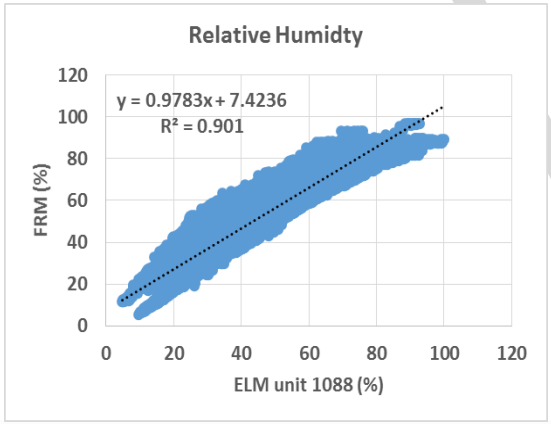


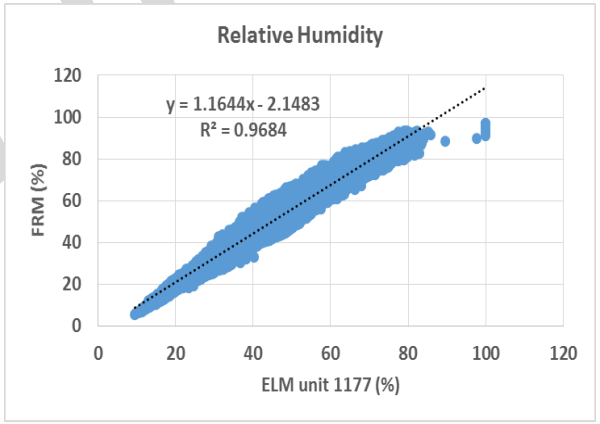


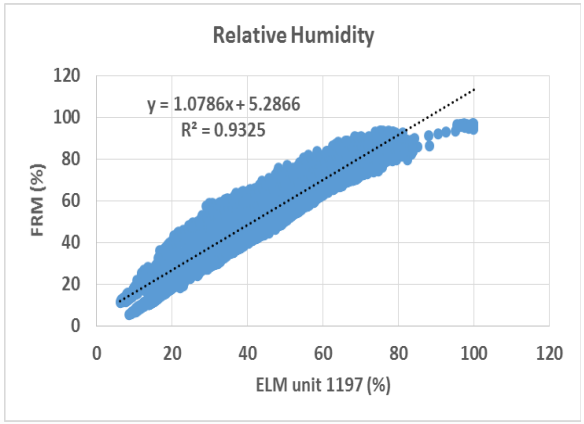
Relative Humidity (5-min mean)



- ELM Relative Humidity measurements show excellent correlation with the corresponding Station RH data ($0.90 < R^2 < 0.97$)







Discussion

- Overall, the three ELM monitors were reliable (i.e. no down time over a period of about two months) and they showed modest to low intra-model variability for all measured pollutants (except PM_{10}) and meteorological variables
- The ELM ozone sensors showed excellent correlation with a substantially more expensive FRM ozone instrument ($0.89 < R^2 < 0.96$)
- The ELM PM_{10} and NO_2 sensors correlated very poorly with the corresponding FEM instruments data ($0.0 < R^2 < 0.15$)
- NO_2 sensor measurements might have been affected by a potential interference with ozone and/or relative humidity. This will be thoroughly examined during laboratory testing
- Temperature and relative humidity correlated very well ($0.90 < R^2 < 0.97$) with the corresponding weather station data
- No sensor calibration had been performed prior to the beginning of this field testing
- Laboratory chamber testing is necessary to fully evaluate the performance of these sensors under controlled temperature/relative humidity conditions and known gaseous concentrations

- All results are still preliminary