



Vapor Intrusion (VI) Indicators, Tracers, and Temporal Variability of cVOCs in Industrial Buildings

DoD Virginia Site A – Climate Zone 4



EPA VI Workshop, AEHS West Coast Conference, San Diego CA

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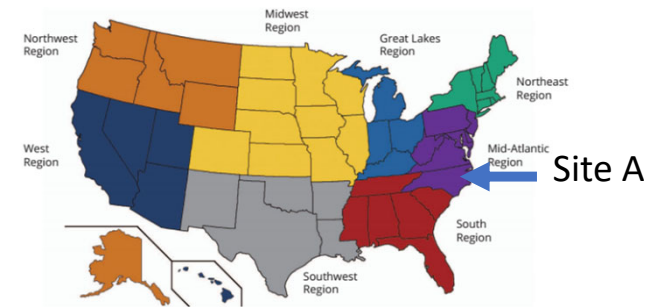
Temporal Variability Study Objectives

- Evaluate temporal variability of cVOCs and indicators/tracers in an industrial building
 - Collect high-frequency (~4 hr intervals) indoor, outdoor, utility penetration, and subslab cVOC data for one year
 - Collect corresponding high-frequency VI indicator/tracer data
 - Evaluate conditions that produce and might predict >95 percentile of indoor air concentrations; including meteorology

Funded under Navy Environmental Sustainability Development to Integration (NESDI) Project 554 With
Additional Data Analysis Funded by EPA

Site Background

- Site located in Mid-Atlantic region
 - Mostly concrete/asphalt-paved industrialized area
 - cVOCs released from damaged industrial wastewater lines
- Medium-to-coarse grain sands in vadose zone
- Depth-to-groundwater: 3 to 8 ft bgs
- Remediation Activities
 - Groundwater extraction and AS/SVE
 - Discontinued in 2012/13 due to limited effectiveness



GW cVOCs Beneath/Near Study Building

cVOCs	Max Concs (2014-16) ($\mu\text{g/L}$)
1,1-DCE	644
1,2-dichloroethane	7.4
Cis-1,2-DCE	474,000
Trans-1,2-DCE	67,700
TCE	898,000
VC	639,000

Va Site A - Matrix of CSM scenario-categories

Type & Depth to VOC source	Building type & size (ft2)	Foundation	Sub-foundation horizontal permeable	Preferential pipe pathway	Bldg-Climate zone (Temp)	Press./ Wind speed & direction	Intrusion primarily Advect. vs Diffusive
Shallow Soil	Modern sub-urban SFR Mod. 2k	Slab-on-Grade	Continuous horizontal/permeable	High	1-3	Low	Advective
Deep Soil	Legacy Urban Multi-Family	Split level – SoG & basmt	Discontinuous /impermeable	Mod.	4	Mod. Incl. 'On-shore' winds	Diffusive
Shallow GW	Non-Res. >10k ft2	Full basement		Low	5	High steady direct	50-50?
'Deep' GW	Non-Res. >100k	Crawlspace -dirt floor		None	6-8	High varying direction	

Field Activities

- Detailed Building Survey and Diagnostic Testing
 - HVAC evaluation (e.g., type, zones, makeup air, operational settings)
 - Tracer gas testing to evaluate air exchange rates
- Building Pressure Control Studies (Near Worst-Case VI)
 - Pressure data, measure flow rates, HAPSITE VOC data, discharge rates
 - Evaluate leakage, entry points, background, flux
- *Year-Long VOC and Indicator/Tracer Studies*
 - Four sampling zones within industrial building
 - High frequency indoor, subslab, and outdoor air cVOCs and radon
 - IA/OA (continuous) and subslab (monthly) radon
 - Continuous pressure and temperature differential data
 - Meteorological data near building
- Presenting 9 months of data (May '19 – Feb '20)
 - More data collection/analyses underway, which will also include wind and precipitation analyses

RadonEye (IA/OA)



<http://radonftlab.com/radon-sensor-product/rd200/>

dP and Temp



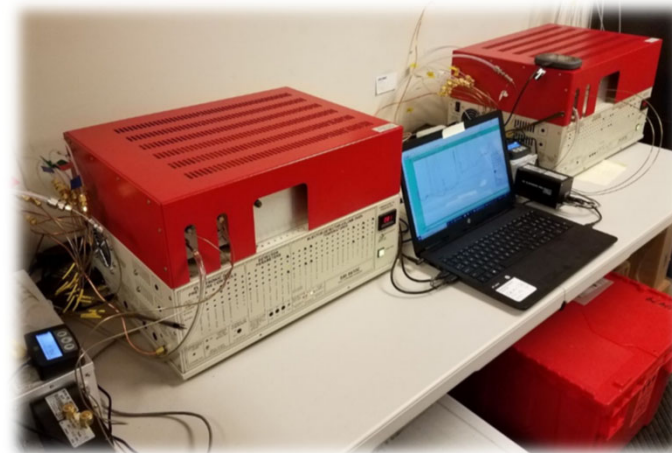
https://www.omegaeng.cz/ppts_t_eng/OM-CP-PRTC110.html

RAD7 (subslab RN)



<https://durrige.com/products/rad7-radon-detector/>

GC/ECD (cVOCs)



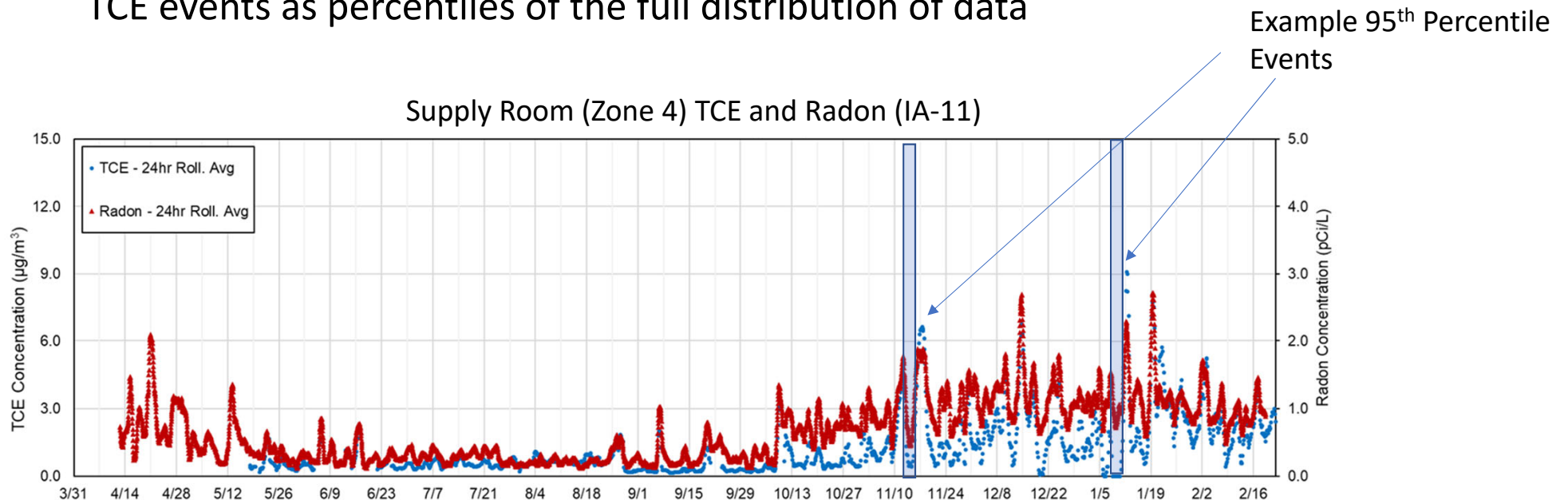
Weather Station



<https://www.davisinstruments.com/solution/vantage-vue/>

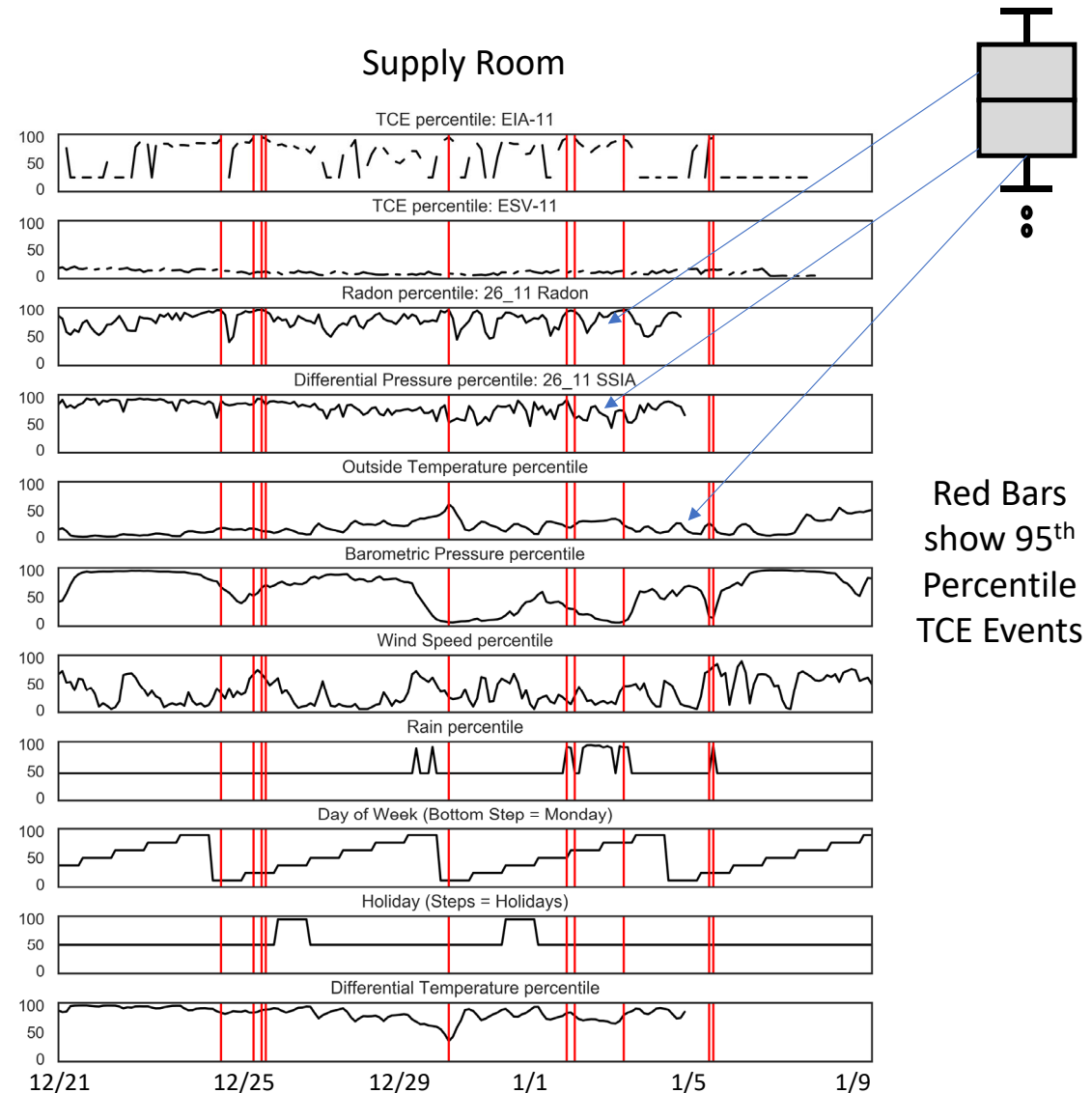
Can ITS be used to Predict High TCE Events?

- Data collected during the year-long study used to analyze ITS leading up to the high TCE events (95th percentile events)
 - 64 events from May 16, 2019 to January 10, 2020
 - Box and whisker plots in subsequent slides show ITS data leading up to the 64 high TCE events as percentiles of the full distribution of data

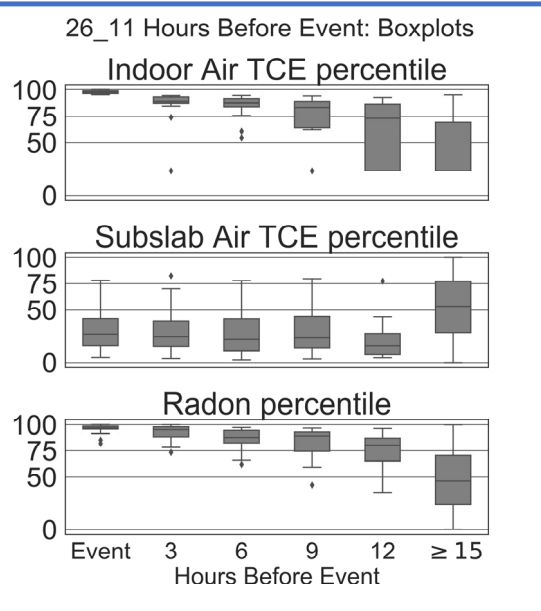


Virginia Site A, Example High Concentration Events

- **Objective:** Determine if ITS can be used to predict high (95th percentile) TCE events
- Ten high TCE events from December and early January are shown here as red bars (as examples)
- Percentiles for ITS data in the 5 days leading up to the high TCE events compiled into box and whisker plots
 - Relative to the full distribution

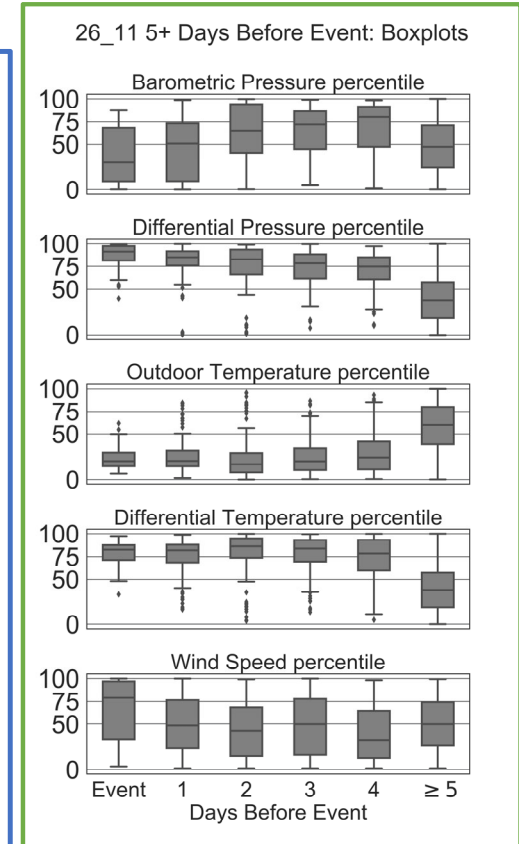
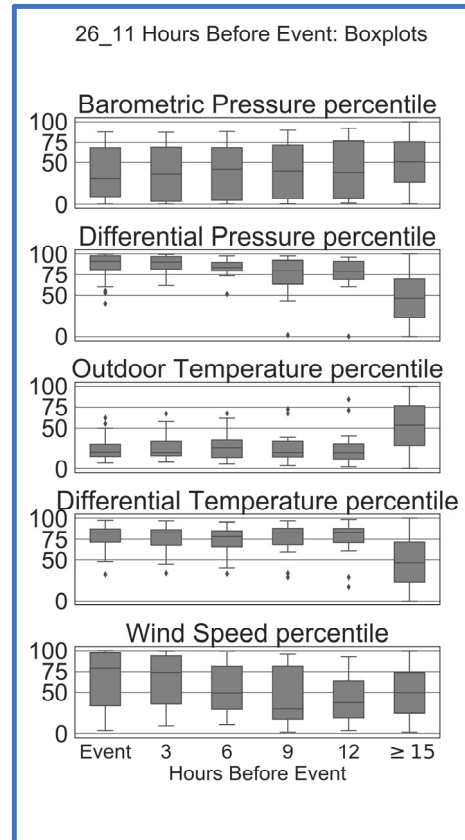
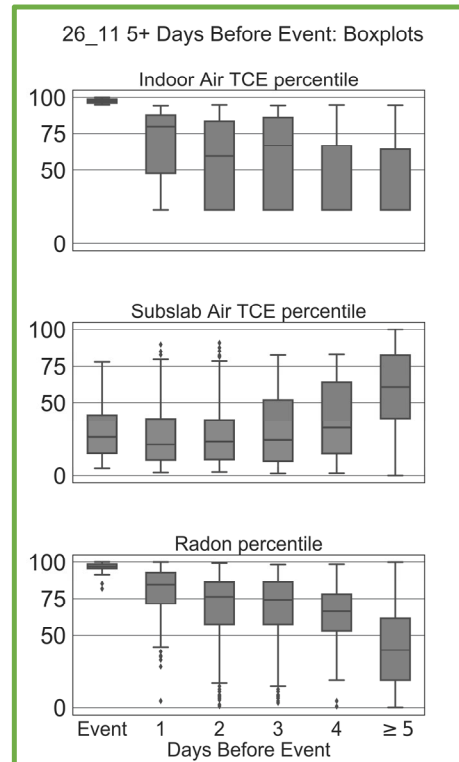


Indicators Preceding >95% TCE Observations: Supply Room (Zone 4)

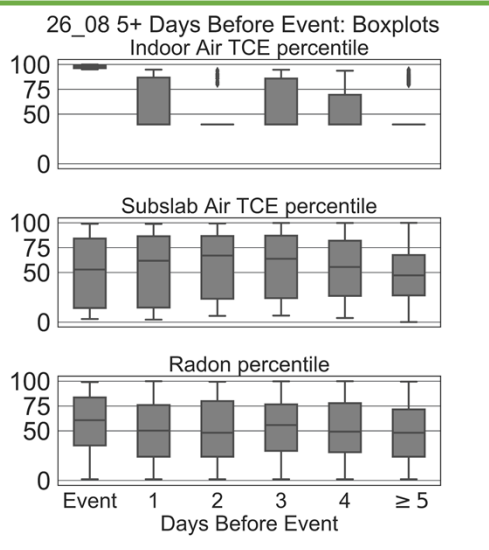
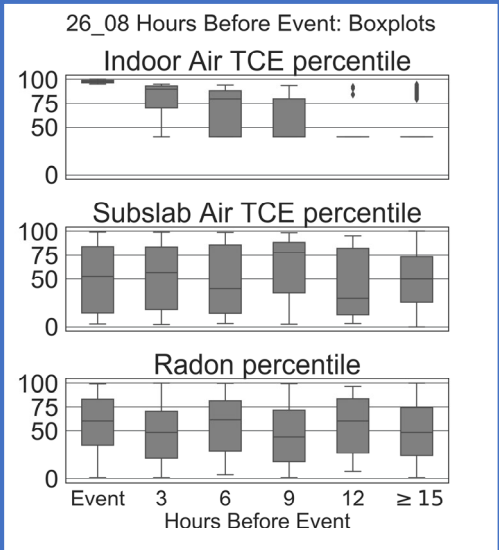


*Box and whiskers include data from all events within the entire dataset

- Increasing and high radon is a good tracer in the supply room
- ΔP is a good indicator
- Cold but not the coldest temperatures associated with high TCE

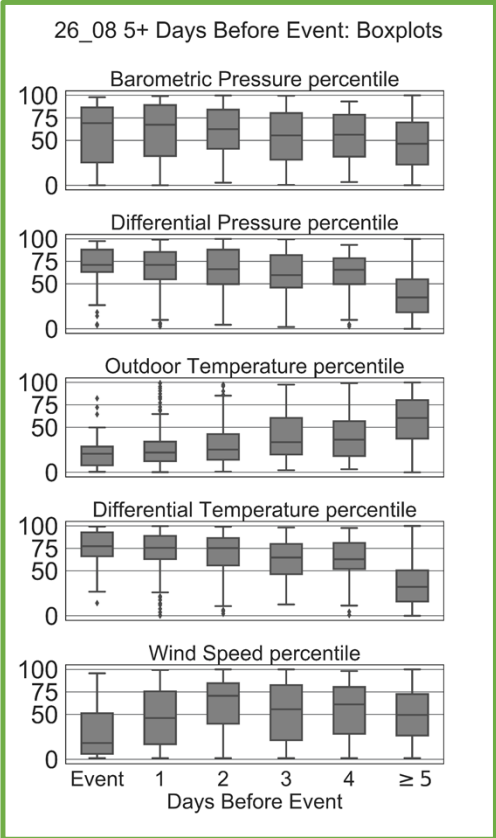
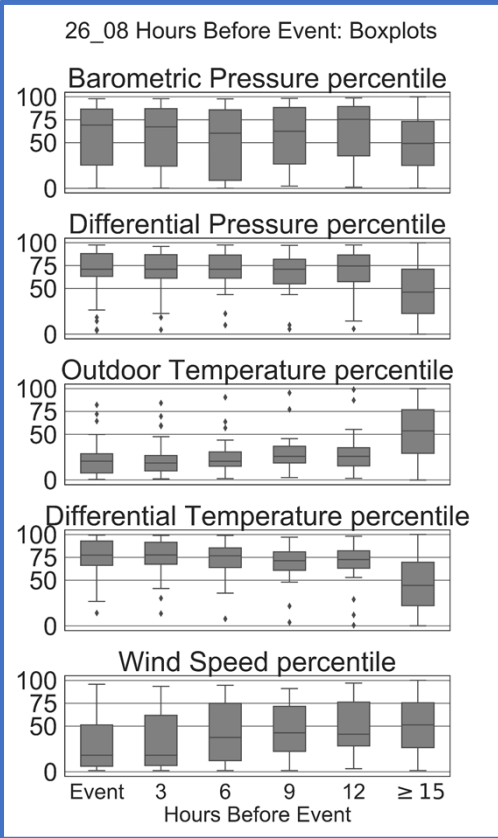


Indicators Preceding >95% TCE Observations: Women's Bathroom

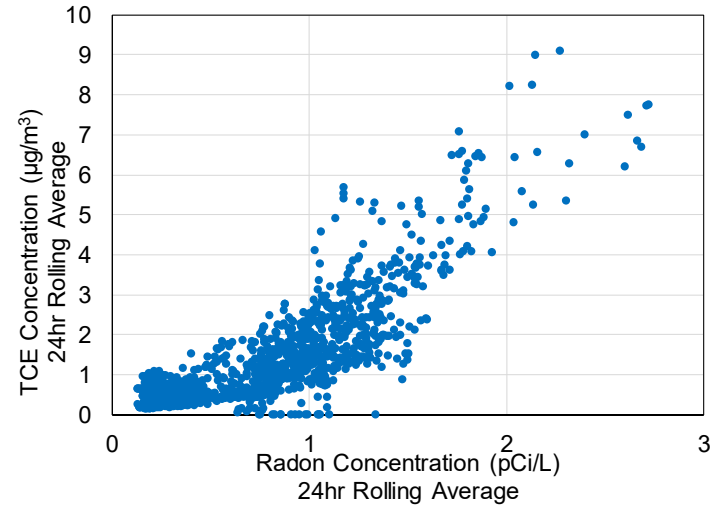


*Box and whiskers include data from all events within the entire dataset

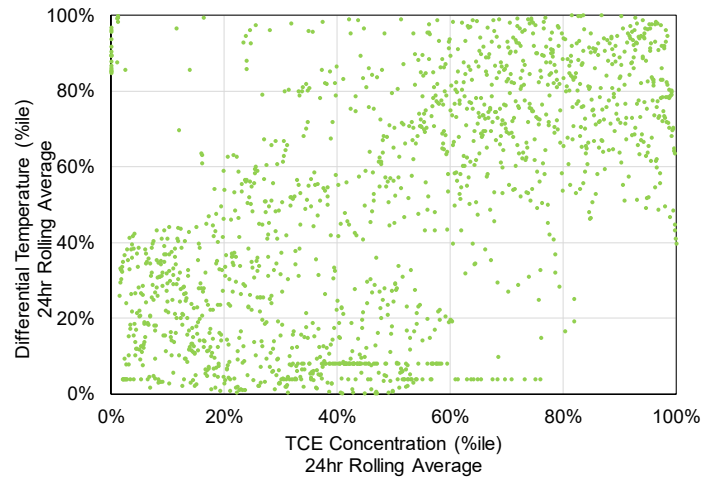
- Radon not well correlated in bathroom
- Colder outdoor temperatures may be associated with higher TCE events
- Lower wind speeds observed at time of high TCE events and up to ~6 hrs prior



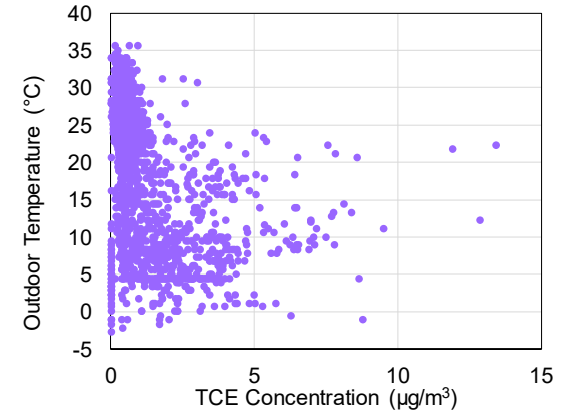
Radon vs. TCE
EIA-11



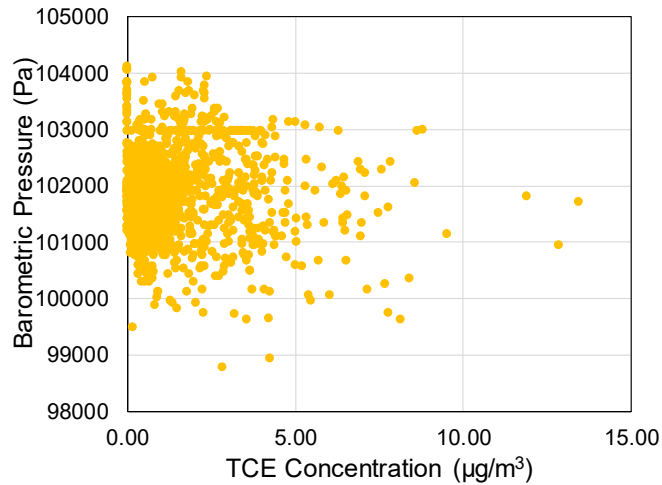
TCE vs. Differential Temperature
Percentiles: EIA-11



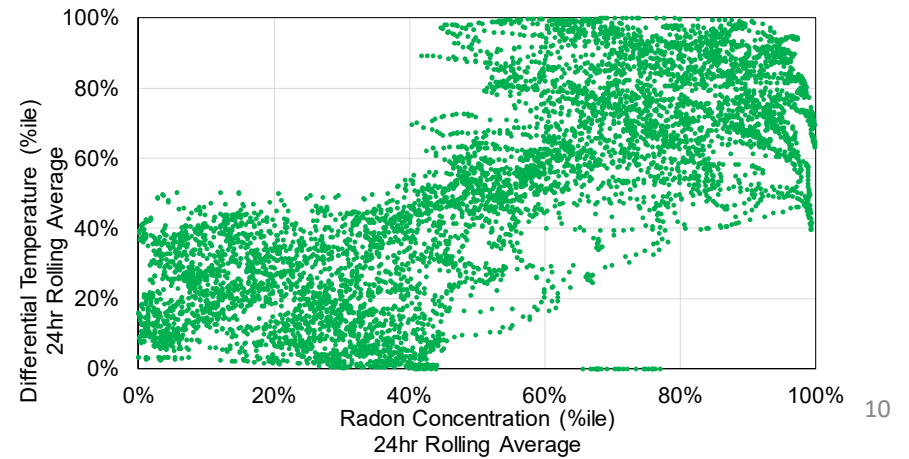
TCE vs. Outdoor Temperature
EIA-11



TCE vs. Barometric Pressure
EIA-11

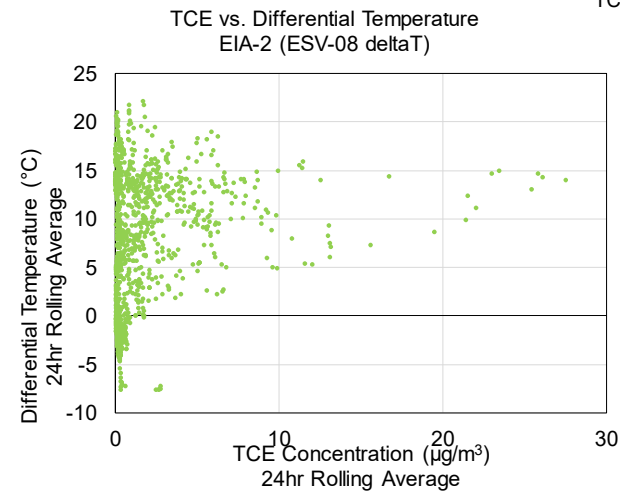
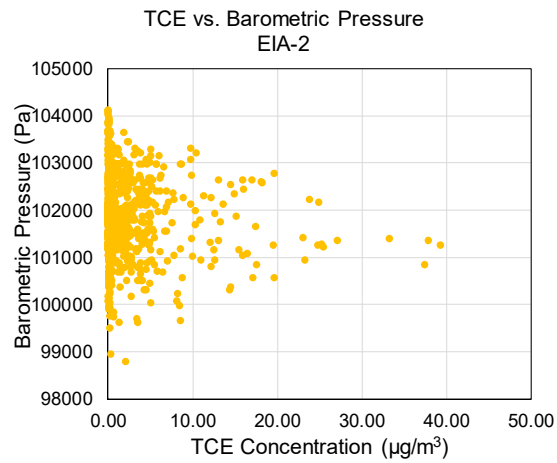
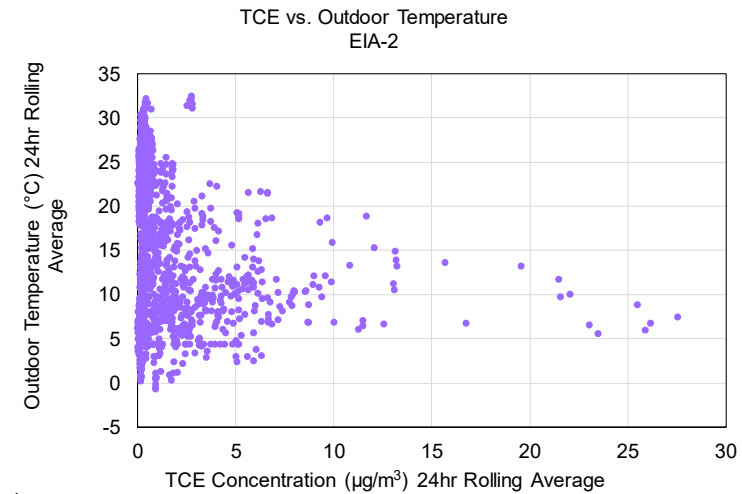
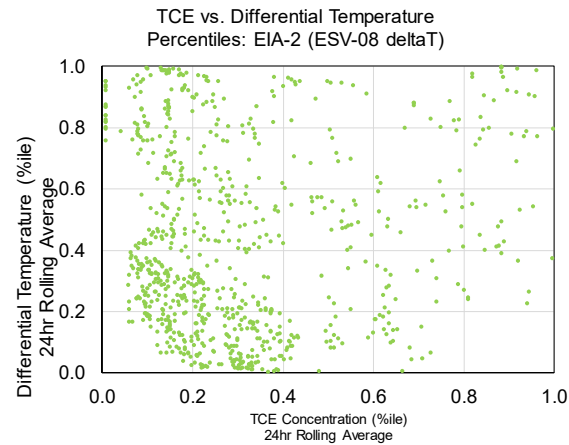
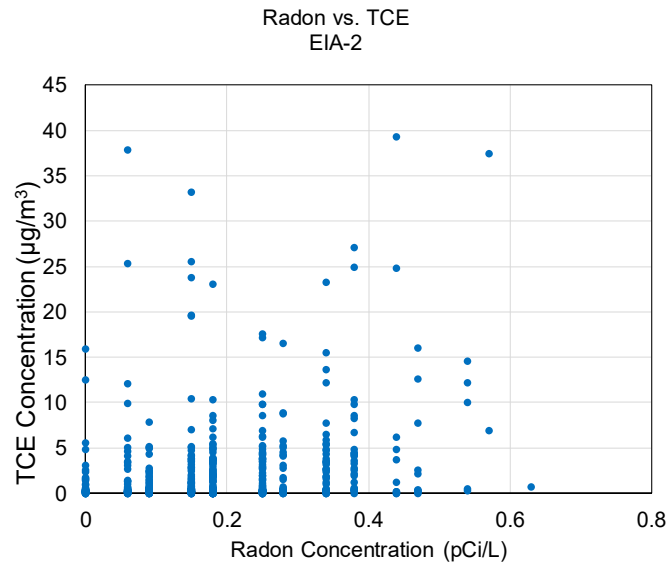


Radon vs. Differential Temperature Percentiles: EIA-11



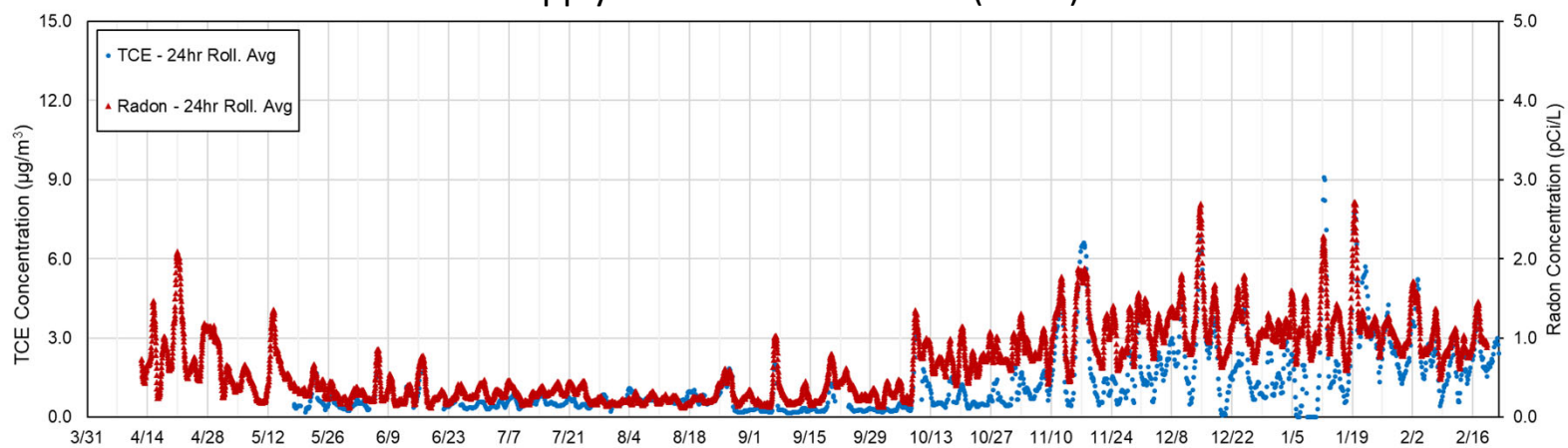
TCE vs.
Indicators
/ Tracers
Across Full
Range
With No
Time Lag –
Supply
Room

TCE vs.
Indicators/
Tracers
Across Full
Range
With No
Time Lag –
Women's
Bathroom

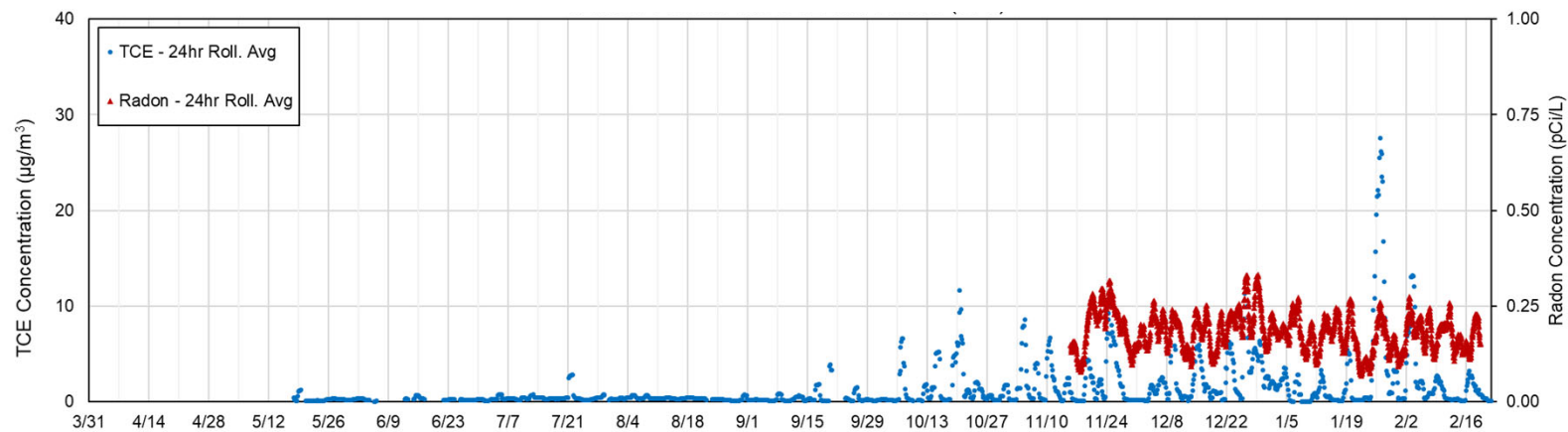


Radon as an Indicator

Supply Room TCE and Radon (IA-11)



Women's Bathroom (TCE and Radon (IA-2)



Conclusions

- Can ITS be used to predict higher TCE event?
 - Sometimes...
 - Radon and differential pressure appear to be the indicators most closely correlated with high TCE in some sampling zones, but not all zones.
 - Not all higher radon events are correlated with high TCE events.
 - Higher TCE concentrations were observed during cold weather, but not necessarily associated with the coldest temperatures.
- Data collection is on-going and additional statistical analysis is planned following completion of the field program.