

LEVERAGING LOW-COST SENSORS FOR AIR MONITORING

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AIR SCIENCES INC.

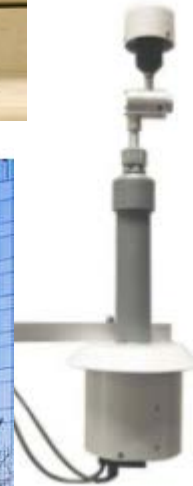
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Overview

- The wild west of low-cost sensors
- Case Studies
- Interpret Data with Caution
- The original low-cost sensors (filters)
- Summary

Lots and lots and lots of options

- Particulate Matter
- Ozone
- NO₂
- VOCs
- CO
- SO₂
- CO₂
- etc.



Even more non-Regulatory options



Where to find information

<http://www.aqmd.gov/aq-spec/evaluations/field>

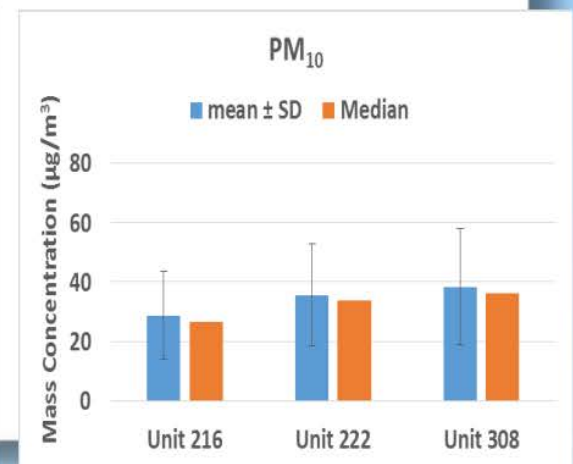
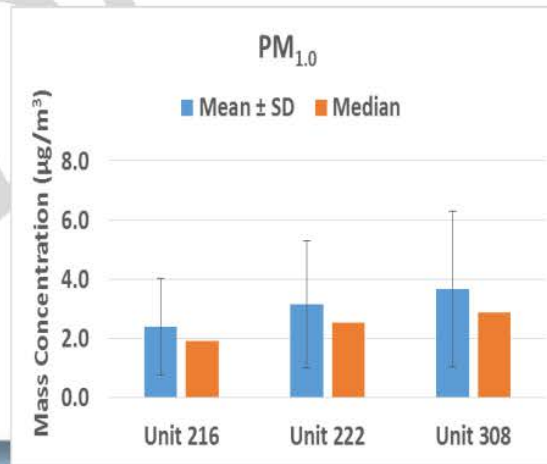
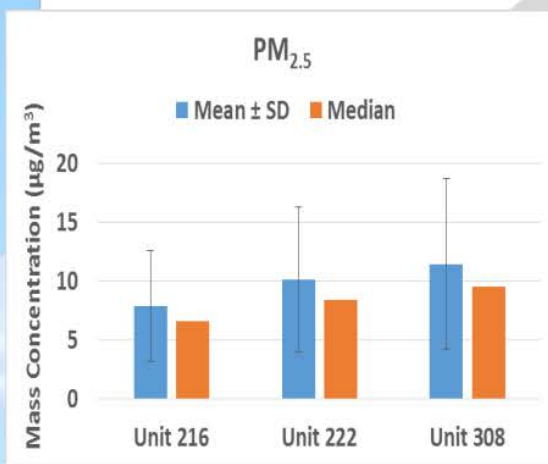
- AlphaSense(3 units tested):
 - Particulate matter sensors (**optical; non-FEM**)
 - Each unit measures: PM_{1.0}, PM_{2.5} and PM₁₀ (µg/m³)
Unit cost: ~\$450
 - Time resolution: 15-sec
 - Units IDs: 216, 222, 308
- M
- G



Where to find information

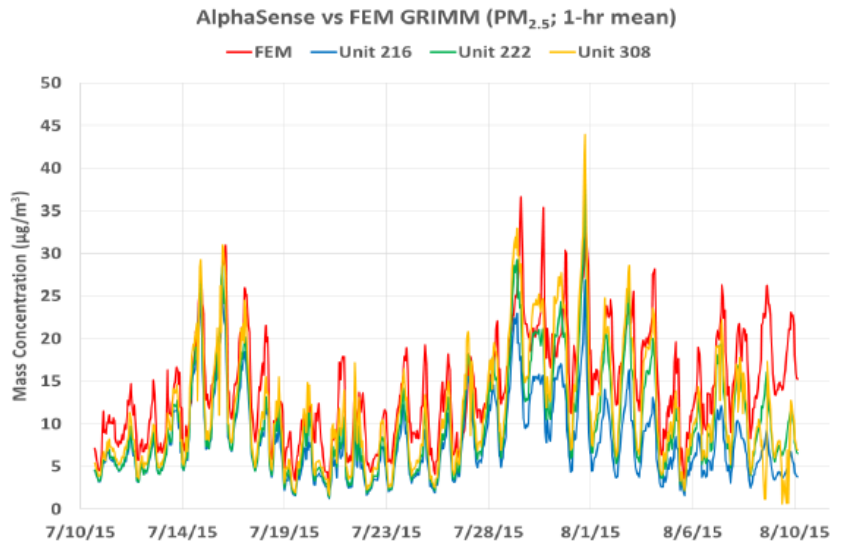
AlphaSense; intra-model variability

- Modest measurement variability was observed between the three AlphaSense OPC-N2 units tested

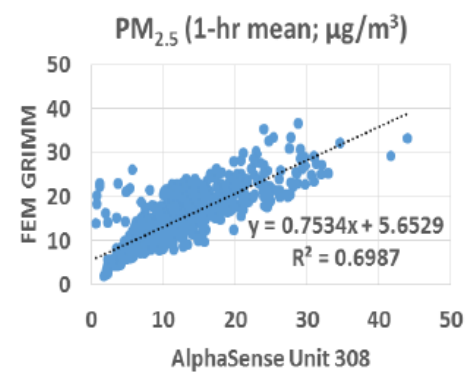
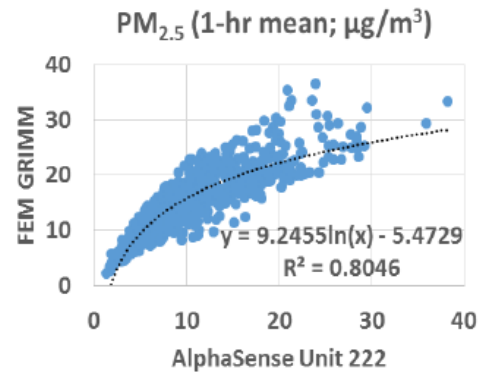
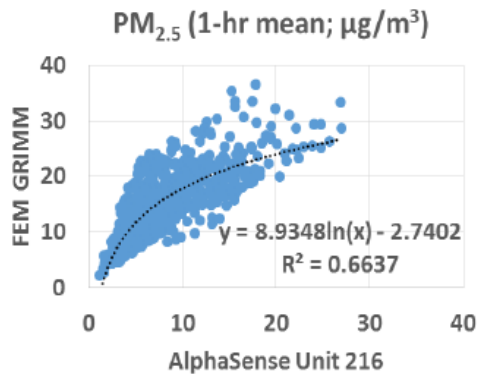


Where to find information

AlphaSense vs FEM GRIMM (PM_{2.5}; 1-hr mean)



- PM_{2.5} measurements from all three AlphaSense sensors correlate well with the corresponding FEM GRIMM data ($0.66 < R^2 < 0.80$)
- AlphaSense measurements seem to track well the typical PM_{2.5} diurnal variations recorded by the FEM instrument

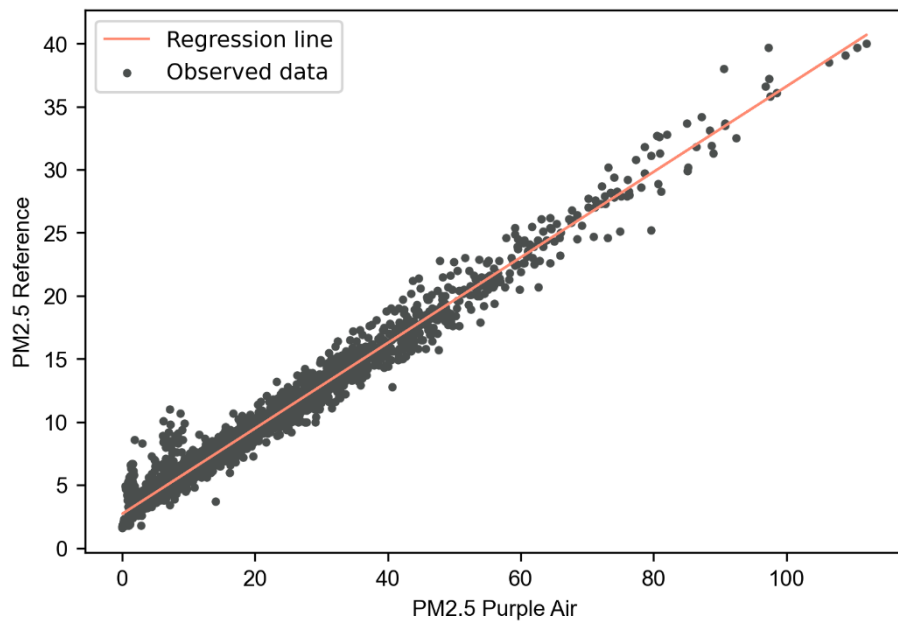


Considerations

- Timeframe
- Accessibility to reference monitors
- Proximity to reference monitors
- Spatial distribution
- Objective of measurements
- Do I need meteorological data?
- Is there a monthly contract? Hot swap?
Data flow?

Calibrations

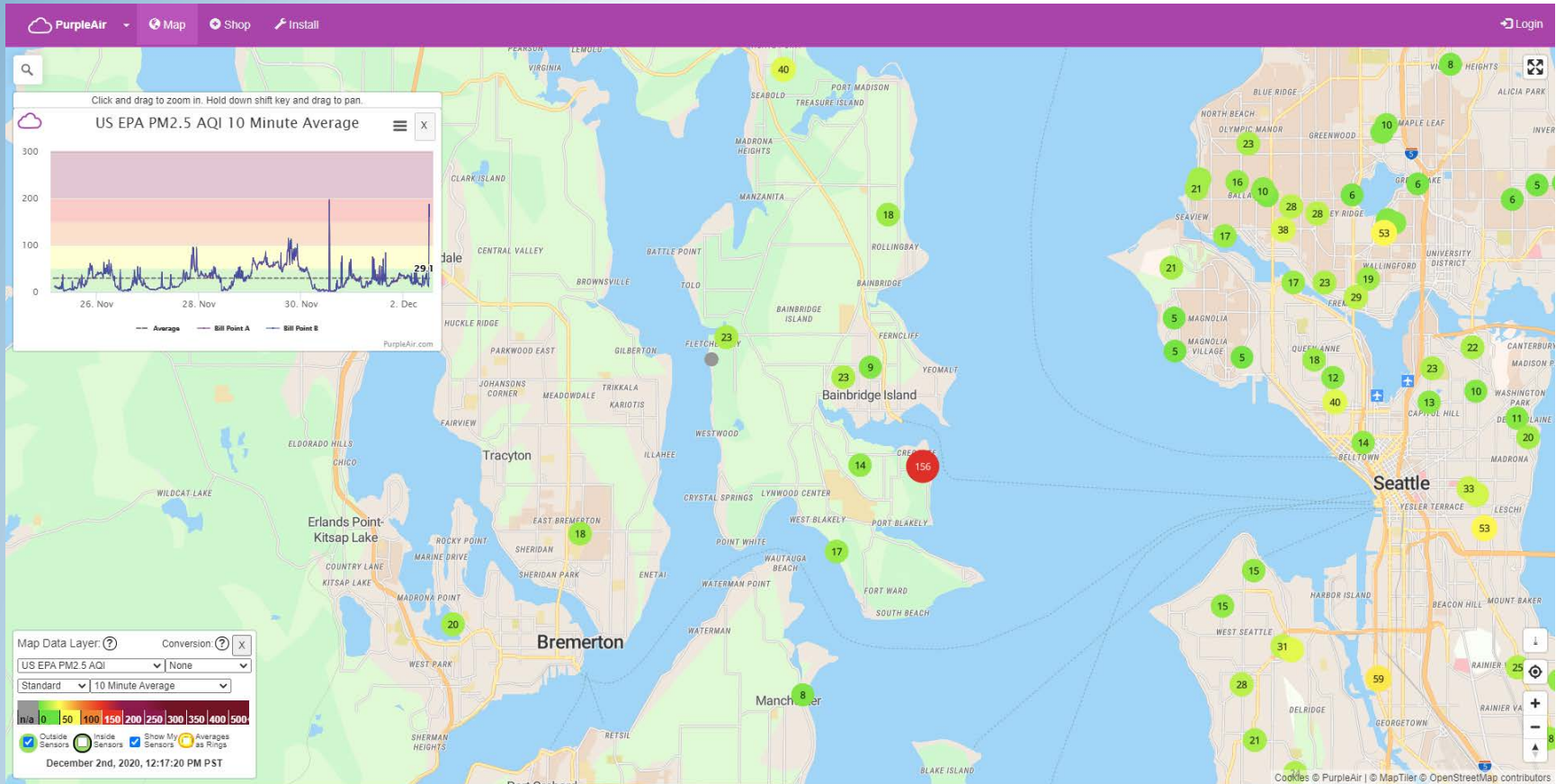
- Need to compare with a regulatory monitor
- Recommended to have collocations for at least a month, ideally once a year



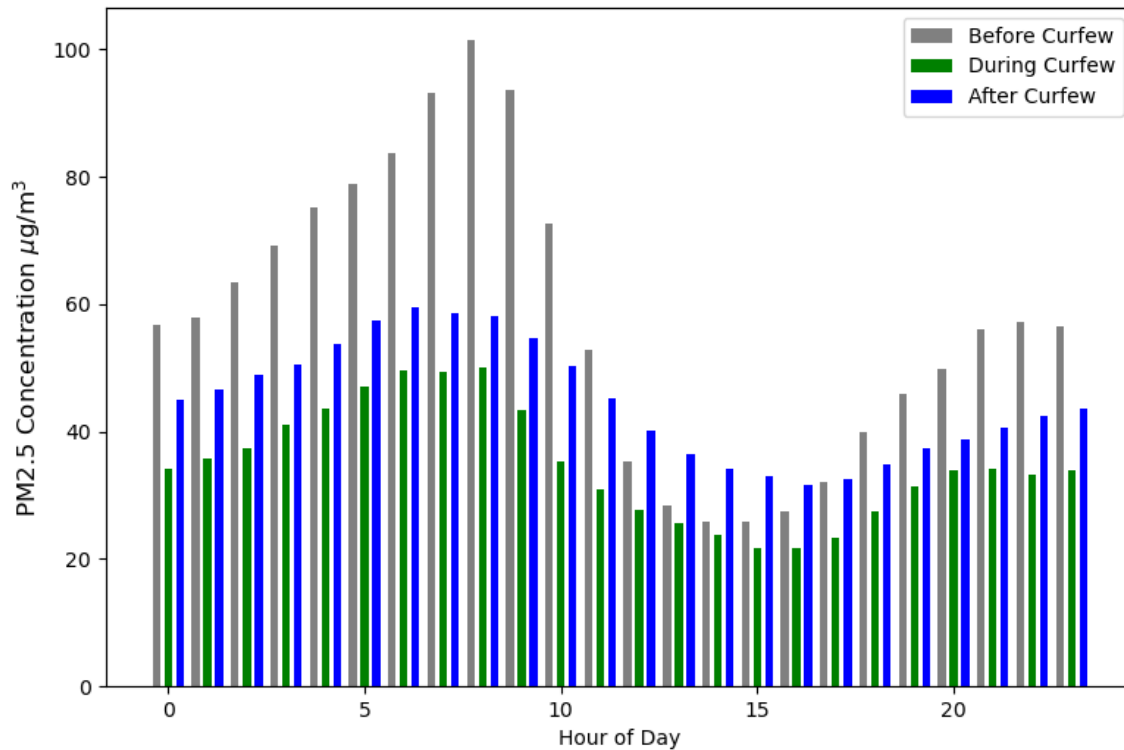
Using the Data

- Ensure proper siting
- Collocate early and often
- Purchase or rent a monitor to meet your needs
- Review data for quality

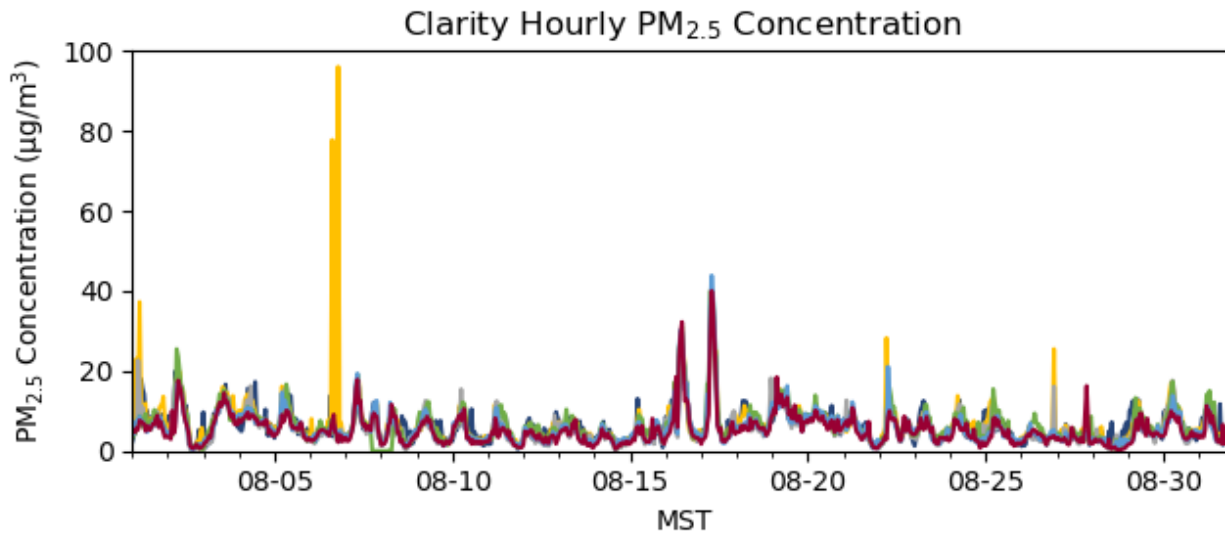
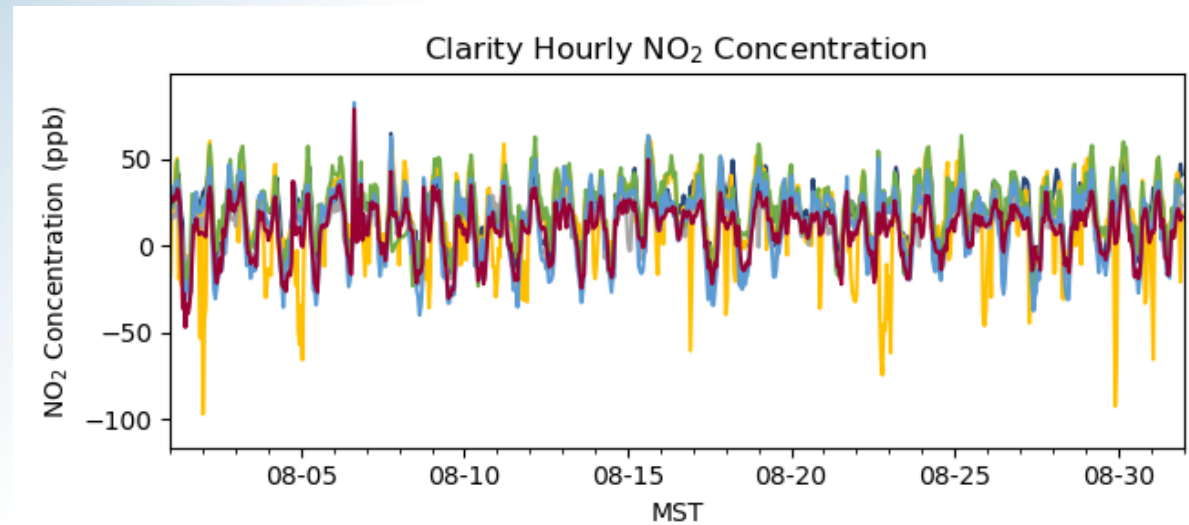
Hot Spot Determination



Trend Analysis – Impact of COVID-19 Curfew



NO₂ Data Example



Limitation : Flow Rate and Inlet Design

- PM_{10} Inlet heads
 - Size selective with 50% cut-point diameter near $10\ \mu\text{m}$ at designated flow rate
 - Omni-directional
 - Sampling efficiency not affected by ambient wind speeds
- $PM_{2.5}$ impactors
 - Size selective with 50% cut-point diameter near $2.5\ \mu\text{m}$ at designated flow rate

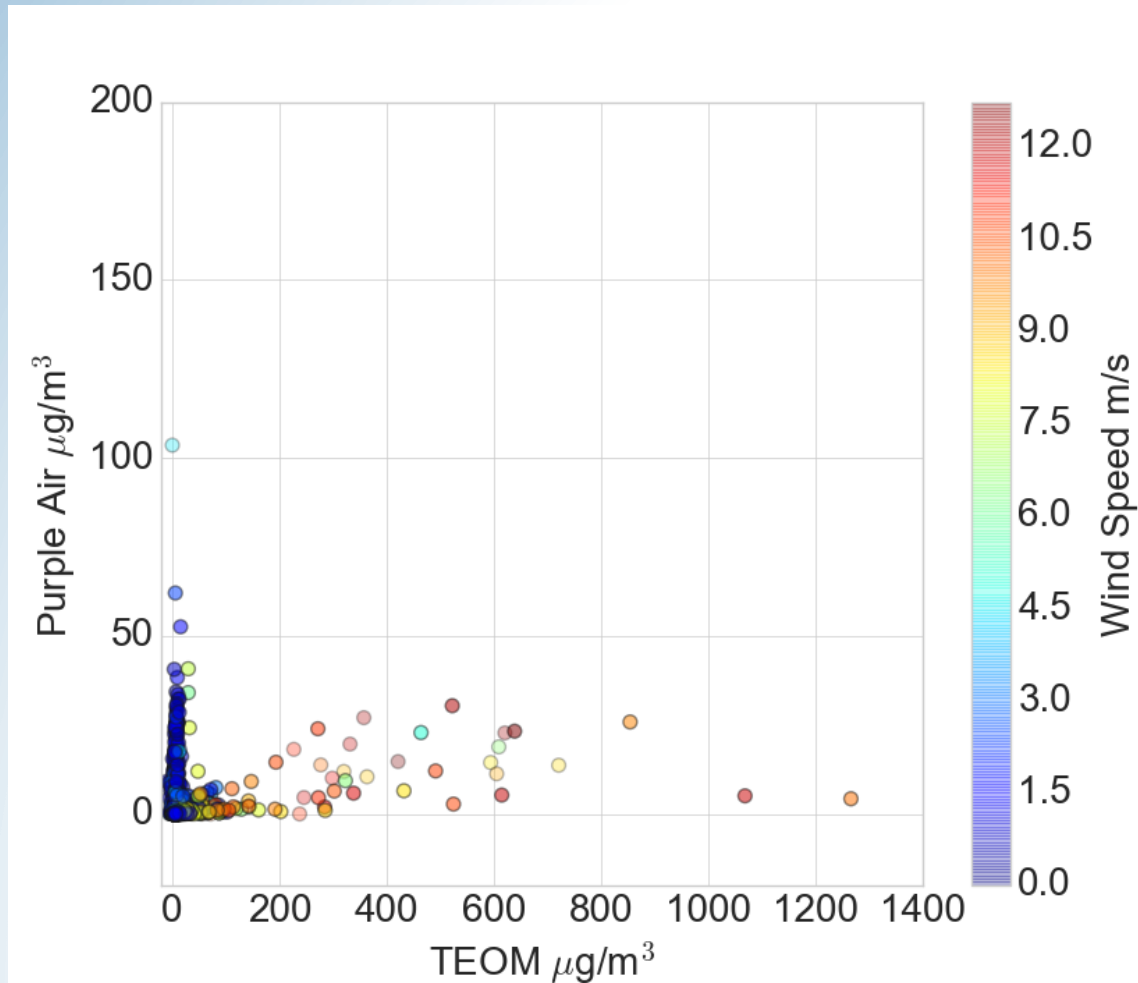


Limitation : Flow Rate and Inlet Design

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Limitation : PM₁₀ Measurements



In my opinion

- Lots of great measurements of PM2.5 – still need calibration
- Some good options for PM10 – at low wind speeds
- NO2 measurements are starting to become reliable
- Ozone – 2B tech always had a ‘low-cost’ option
- Others – still in early stages

Filter-based monitoring

- Not as flashy, easy to use, provides hands on experience
- Filter samples with MiniVol or ARA
- Filter samples for gases with Ogawa or Radiello

Nonmetal Chemical Group Block

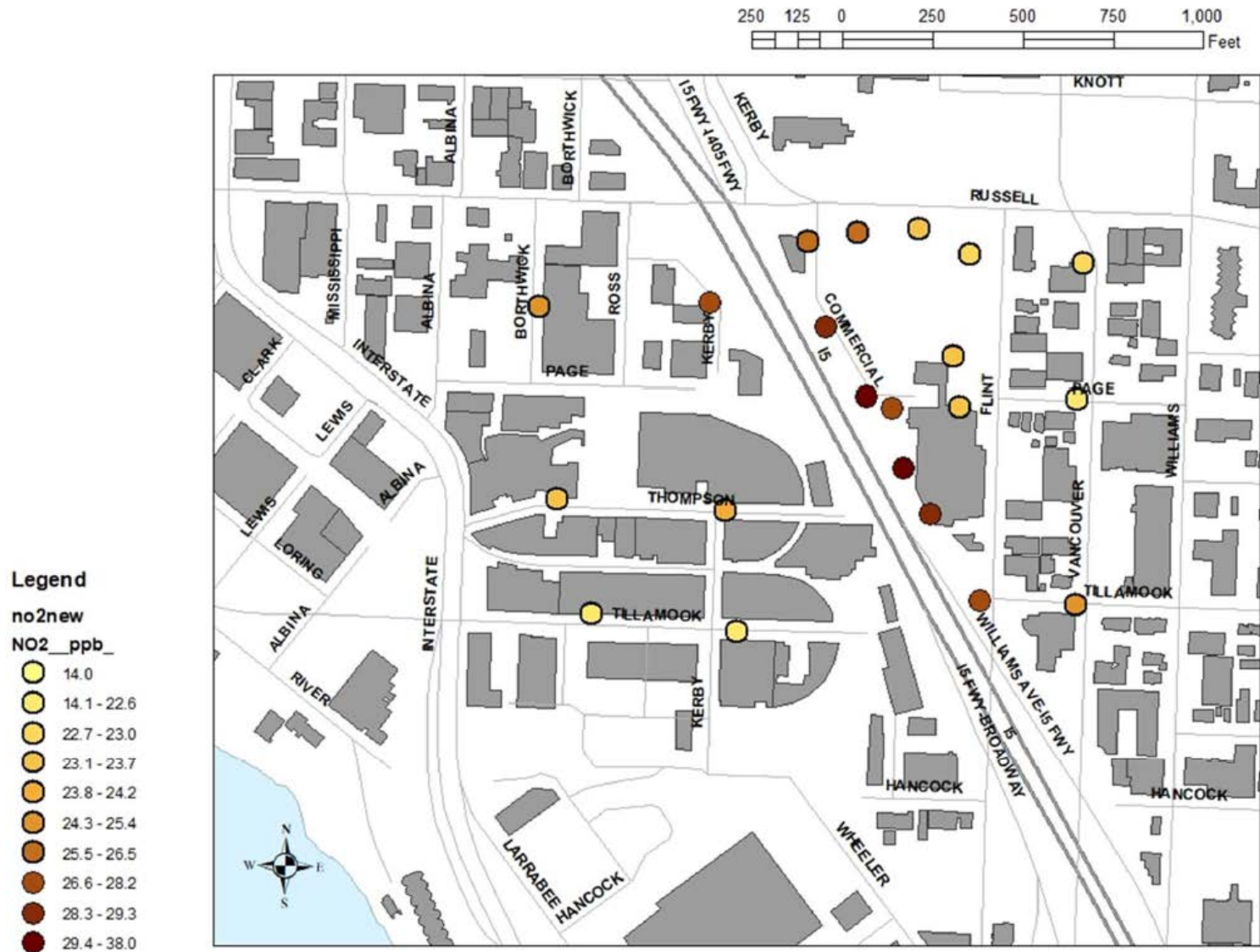
3	11 Na Sodium Alkali Metal	12 Mg Magnesium Alkaline Earth											13 Al Aluminum Post-Transition	14 Si Silicon Metalloid	15 P Phosphorus Nonmetal	16 S Sulfur Nonmetal	17 Cl Chlorine Halogen	18 Ar Argon Noble Gas
4	19 K Potassium Alkali Metal	20 Ca Calcium Alkaline Earth	21 Sc Scandium Transition M	22 Ti Titanium Transition M	23 V Vanadium Transition M	24 Cr Chromium Transition M	25 Mn Manganese Transition M	26 Fe Iron Transition M	27 Co Cobalt Transition M	28 Ni Nickel Transition M	29 Cu Copper Transition M	30 Zn Zinc Transition M	31 Ga Gallium Post-Transition	32 Ge Germanium Metalloid	33 As Arsenic Metalloid	34 Se Selenium Nonmetal	35 Br Bromine Halogen	36 Kr Krypton Noble Gas
5	37 Rb Rubidium Alkali Metal	38 Sr Strontium Alkaline Earth	39 Y Yttrium Transition M	40 Zr Zirconium Transition M	41 Nb Niobium Transition M	42 Mo Molybdenum Transition M	43 Tc Technetium Transition M	44 Ru Ruthenium Transition M	45 Rh Rhodium Transition M	46 Pd Palladium Transition M	47 Ag Silver Transition M	48 Cd Cadmium Transition M	49 In Indium Post-Transition	50 Sn Tin Post-Transition	51 Sb Antimony Metalloid	52 Te Tellurium Metalloid	53 I Iodine Halogen	54 Xe Xenon Noble Gas
6	55 Cs Cesium Alkali Metal	56 Ba Barium Alkaline Earth	*	72 Hf Hafnium Transition M	73 Ta Tantalum Transition M	74 W Tungsten Transition M	75 Re Rhenium Transition M	76 Os Osmium Transition M	77 Ir Iridium Transition M	78 Pt Platinum Transition M	79 Au Gold Transition M	80 Hg Mercury Transition M	81 Tl Thallium Post-Transition	82 Pb Lead Post-Transition	83 Bi Bismuth Post-Transition	84 Po Polonium Metalloid	85 At Astatine Halogen	86 Rn Radon Noble Gas
7	87 Fr Francium Alkali Metal	88 Ra Radium Alkaline Earth	**	104 Rf Rutherfordium Transition M	105 Db Dubnium Transition M	106 Sg Seaborgium Transition M	107 Bh Bohrium Transition M	108 Hs Hassium Transition M	109 Mt Meitnerium Transition M	110 Ds Darmstadtium Transition M	111 Rg Roentgenium Transition M	112 Cn Copernicium Transition M	113 Nh Nihonium Post-Transition	114 Fl Flerovium Post-Transition	115 Mc Moscovium Post-Transition	116 Lv Livermorium Post-Transition	117 Ts Tennessine Halogen	118 Og Oganesson Noble Gas

Filter-based monitoring

- Ogawa - NO, NO₂, NO_x, SO₂, O₃, NH₃
- Radiello – Aldehydes, NH₃, BTEX/VOCs, HCl, HF, NO₂, SO₂, H₂S, O₃, Phenols, 1,3-butadiene
- Ammonia Deposition Network



Case Study



Summary

- Pick a monitoring technology suited to the project objectives
- Research types of monitoring available
- Be prepared to apply calibrations to data every year