Near-Roadway Exposure to Air Pollution
with Examples from a Study of MSATs at Three Schools Next to U.S. 95 in Las Vegas, NV

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Air Quality Research and Innovative Solutions

Near-Roadway Exposures – Outline

- Near-source (primary) pollutants, in context
- Introduction to U.S. 95 MSAT (Mobile Source Air Toxics) Study
- Monitoring sites at schools, parameters measured
- Typical characteristics of CO, NO/NO_x, and black carbon (BC) at these sites
- Example of upwind/downwind BC concentrations
- Example of hydrocarbon concentrations
- Preliminary summary of MSAT characteristics
- Mitigation Lessons Learned

Primary and Regional Pollutants

Potential Sources	Near-Source Pollutants			Ozone Precursors and Other Regional Pollutants
	PM	BC	MSAT	
Cars/Trucks/Buses	✓	✓	✓	✓
Rail	✓	✓	✓	✓
Ships	✓	✓	✓	✓
Ag Operations				✓
Refineries	✓	✓	✓	✓
Power Plants (gas)				✓
Forest/Ag/Grass Fires				✓
Fireplaces/Woodstoves	✓	✓	✓	
Wind-blown Dust	✓			✓

U.S. 95 Settlement Agreement

Court Settlement Agreement between Sierra Club and NDOT/FHWA regarding urban freeway expansion where three schools are adjacent to roadway

Required components of settlement

- MSAT monitoring study at schools (this study)
- Filtration added to HVAC systems at schools
- Bus retrofit program
- Bus idling education
- FHWA gradient study (with EPA, ongoing research)

Introduction to U.S. 95 MSAT Study

MSAT Study Objectives

- Characterize outdoor and indoor concentrations at schools (student exposure)
- Determine U.S. 95 vehicle contributions (before and after new lanes opened)
- Determine MSAT removal efficiencies of new filtration systems

Focus on priority MSATs

- Diesel particulate matter
- Gaseous components: benzene, 1,3-butadiene, acrolein, formaldehyde, and acetaldehyde

U.S. 95 MSAT Study Measurements

Routine Network (May 2007-May 2008)

- Semi-continuous black carbon (Aethelometer) (10 sites)
- CO (3 sites)
- NO/NO_x (1 site)
- Meteorological parameters (4 sites)

Intensive Measurements (May/June 2007, January 2008)

- 2-hr hydrocarbon and carbonyl samples (10 sites)

Routine Traffic Data at Two Locations

- 5-minute traffic counts, by lane, with vehicle-class bins and vehicle speeds

Monitoring Sites at Schools

Fyfe Elementary School Monitoring Sites

Ambient is 20 meters from sound wall (SW); air inlet is 76 meters from SW.

Legend: Air Inlet Classroom Ambient

Western HS Monitoring Sites

Ambient is 136 meters from sound wall (SW); air inlet is 317 meters from SW.

Legend: Air Inlet Classroom Ambient

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Adcock Elementary School Monitoring Sites

Ambient is 17 meters from sound wall (SW); air inlet was 39 meters from SW; air inlet for new system is 33 meters from SW.

Legend: Air Inlet Classroom Ambient

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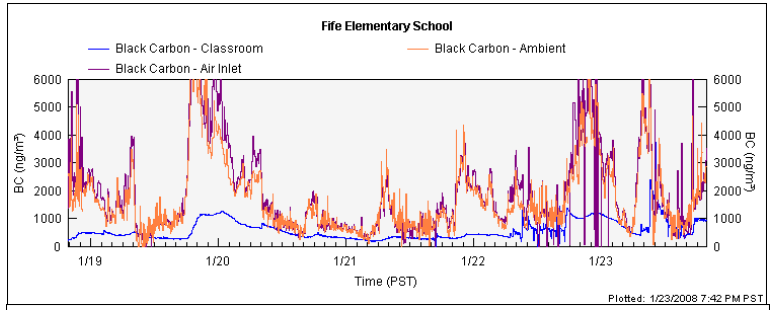
Fyfe Trailer and Shelter Next to Classroom (Before HVAC Changes)

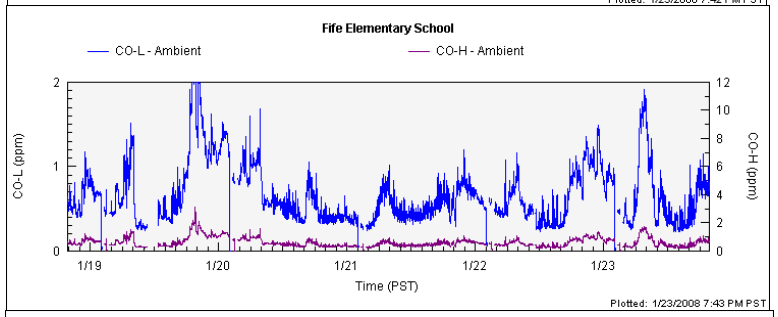
20 meters from sound wall

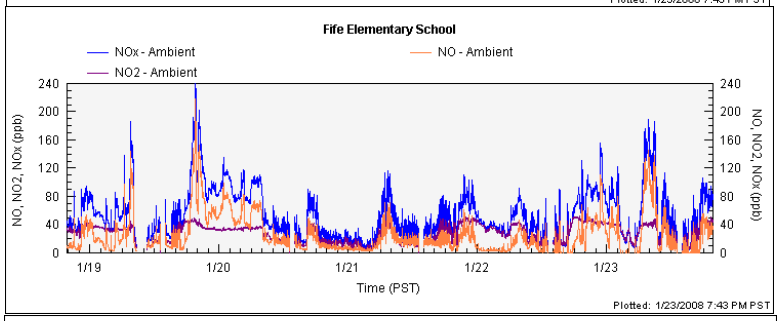
76 meters from sound wall

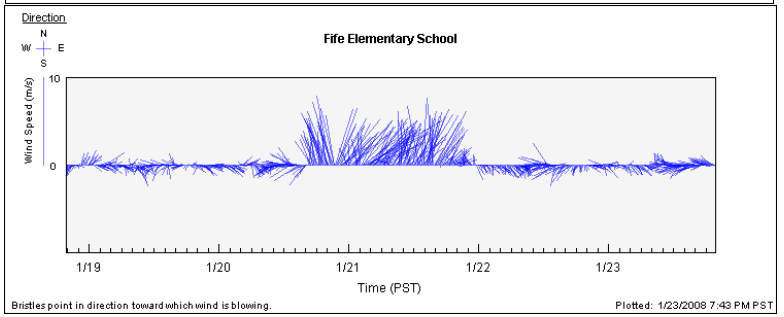
Typical Time-Series of Concentrations at Fyfe in Winter

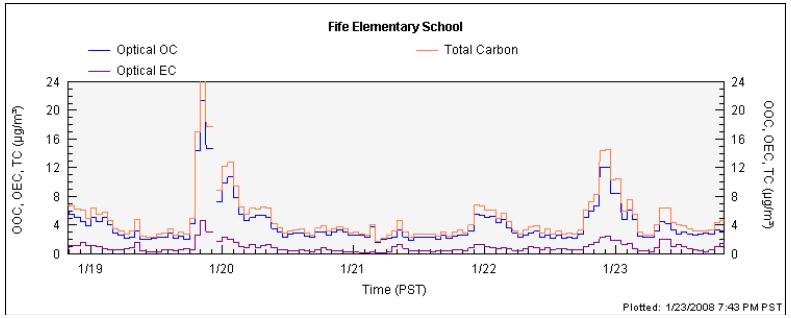
- BC, CO, NO, OC, and EC profiles are similar.
- Wind speed, wind direction, and source strength have a major influence on concentrations.



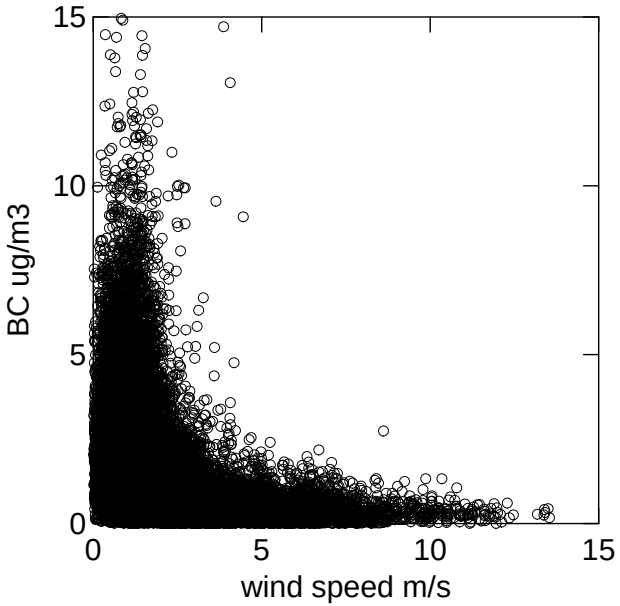




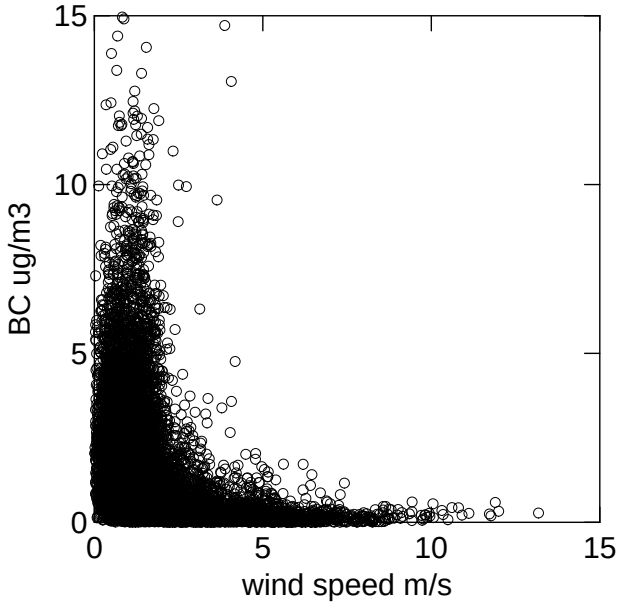




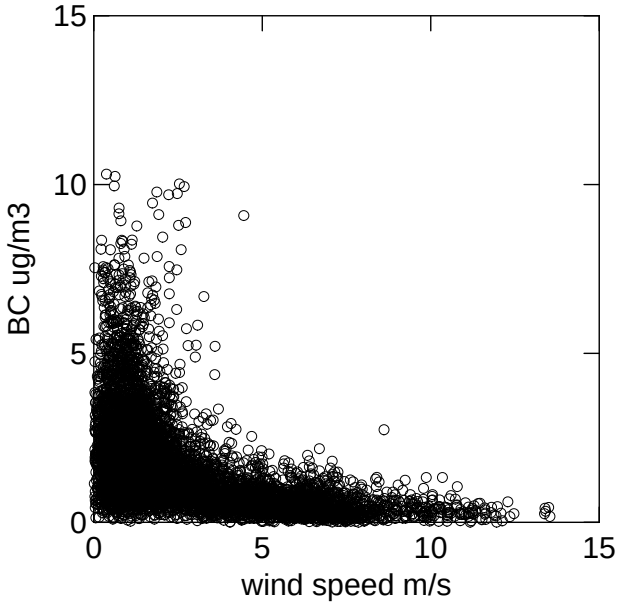
Fyfe, Ambient Monitor, December–Early March



BC vs. windspeed, all hours, N=25,780, 5-min



BC vs. windspeed, all hours, winds from the north, N=12,871



BC vs. windspeed, all hours, winds from the south (freeway), N=6580

High BC concentrations are seen at low wind speeds regardless of direction. Also note that concentrations are higher at wind speeds > 2 m/s when winds are from the south (U.S. 95).

North=290-70 degrees
South=110-250 degrees

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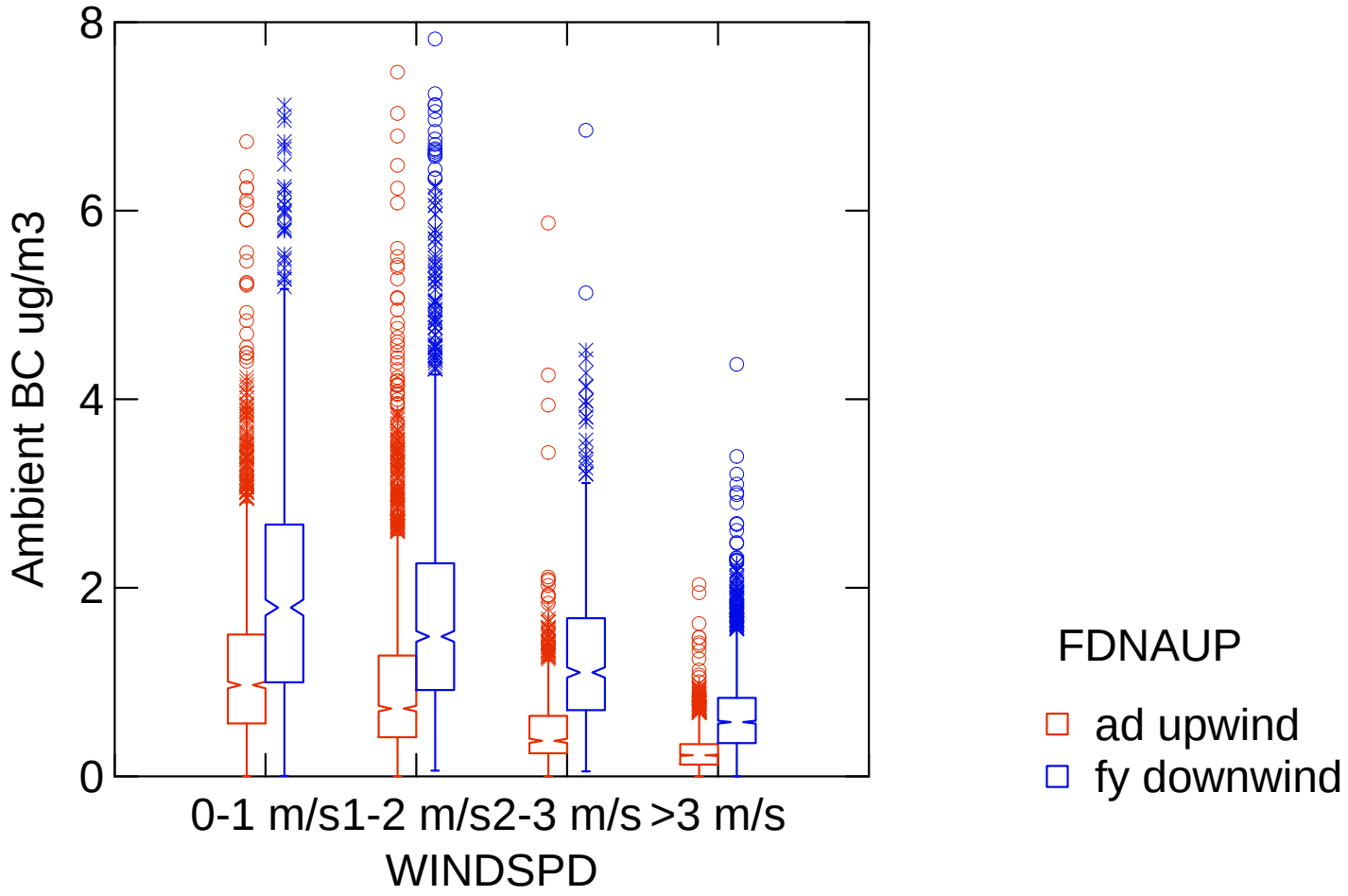
BC Concentrations Upwind and Downwind Influence of Wind Speed



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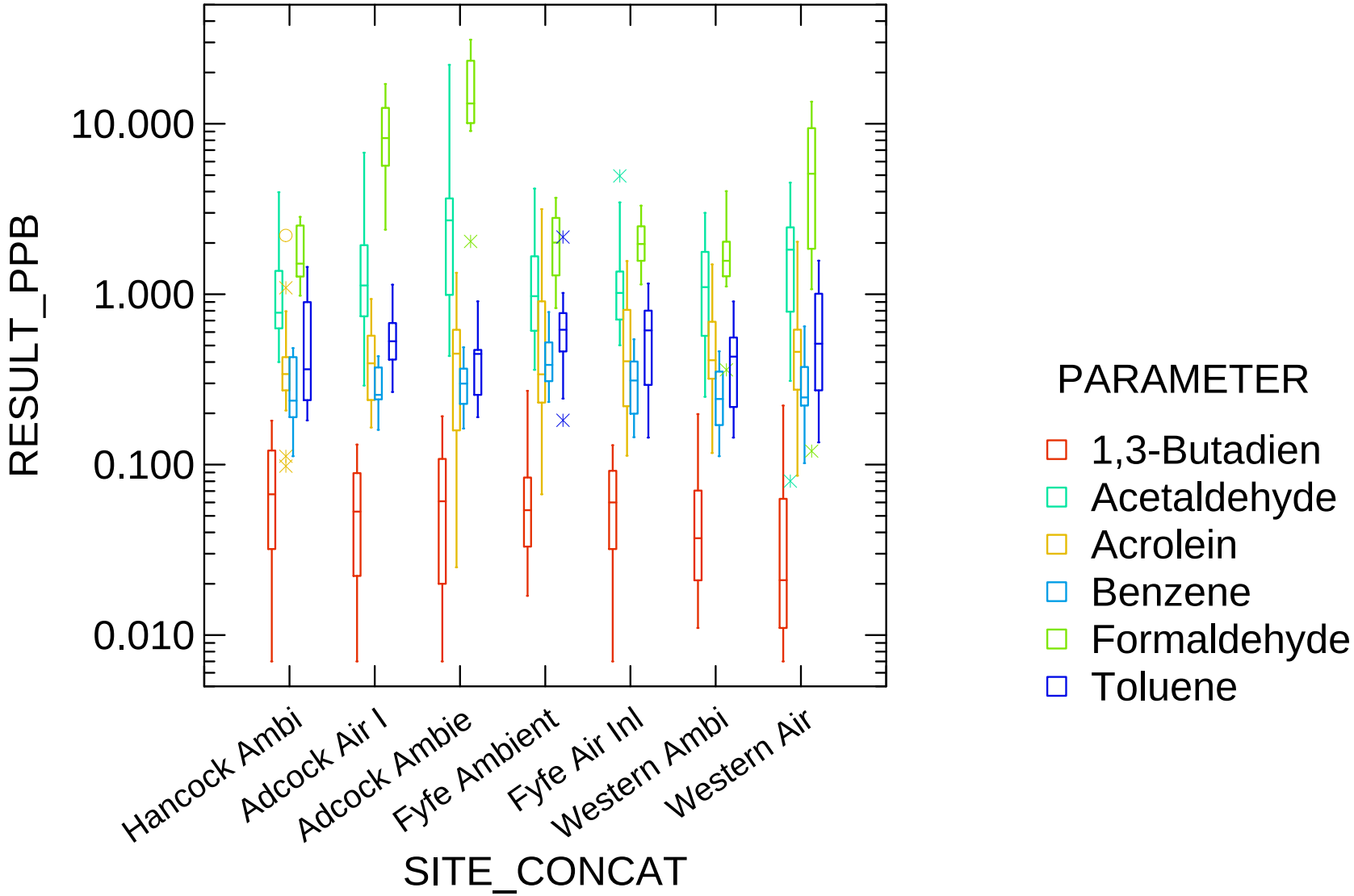
Winter 0900-1100
Gaseous Concentrations Distribution



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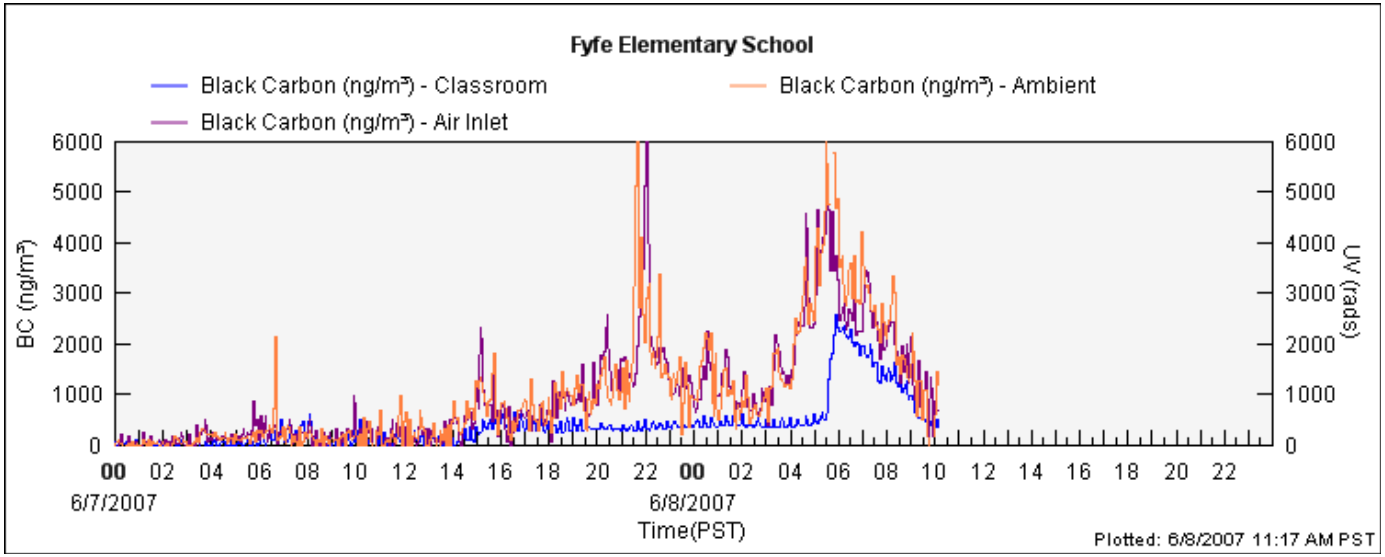
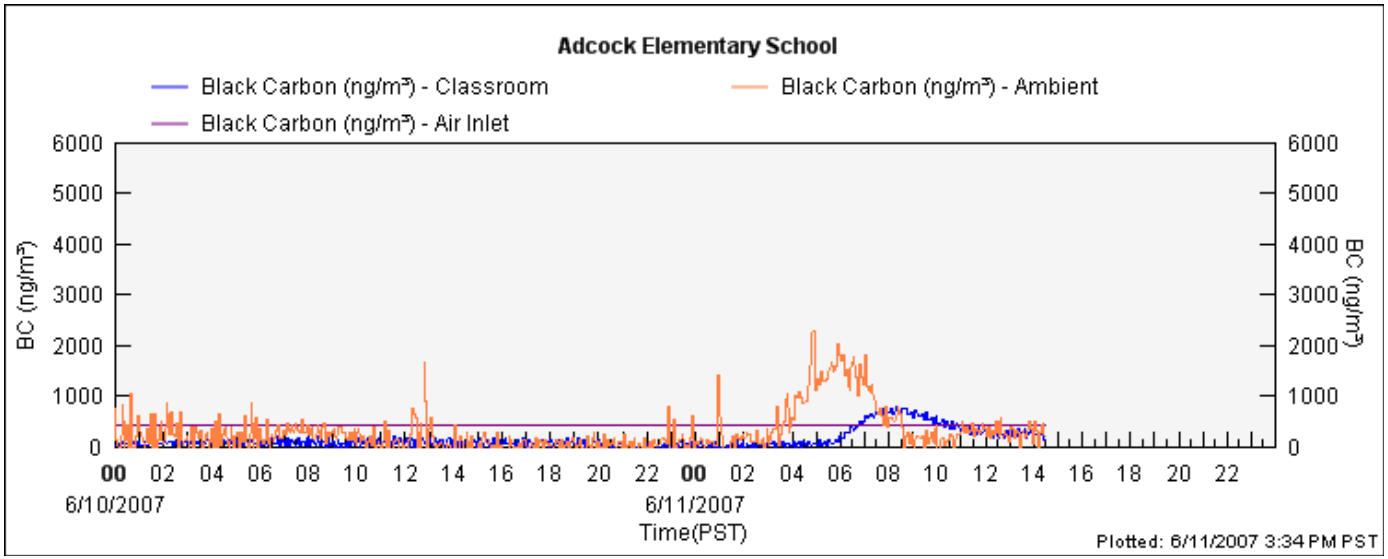
Preliminary Summary of Ambient MSAT Characteristics

- Fresh pollutants go up and down together.
- Morning concentrations dominate indoor and outdoor exposure (summer); overnight and morning concentrations dominate in the winter.
- Expected pollutant gradients are not always evident.
- Low wind speeds often allow high pollutant concentrations on both sides of roadway (with a sound wall).
- Wind conditions and time-of-day have a significant influence on near-roadway exposure.

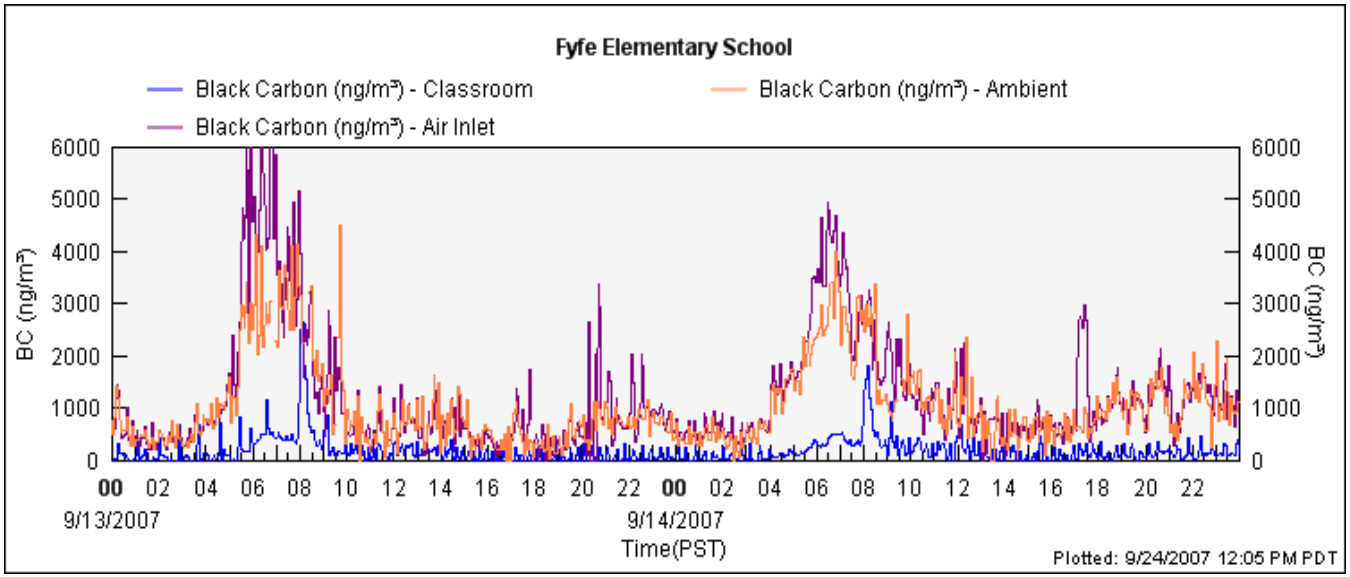
Example BC Time-Series Showing Classroom Being Filled with Rush-hour Pollution by HVAC (Before HVAC Changes)

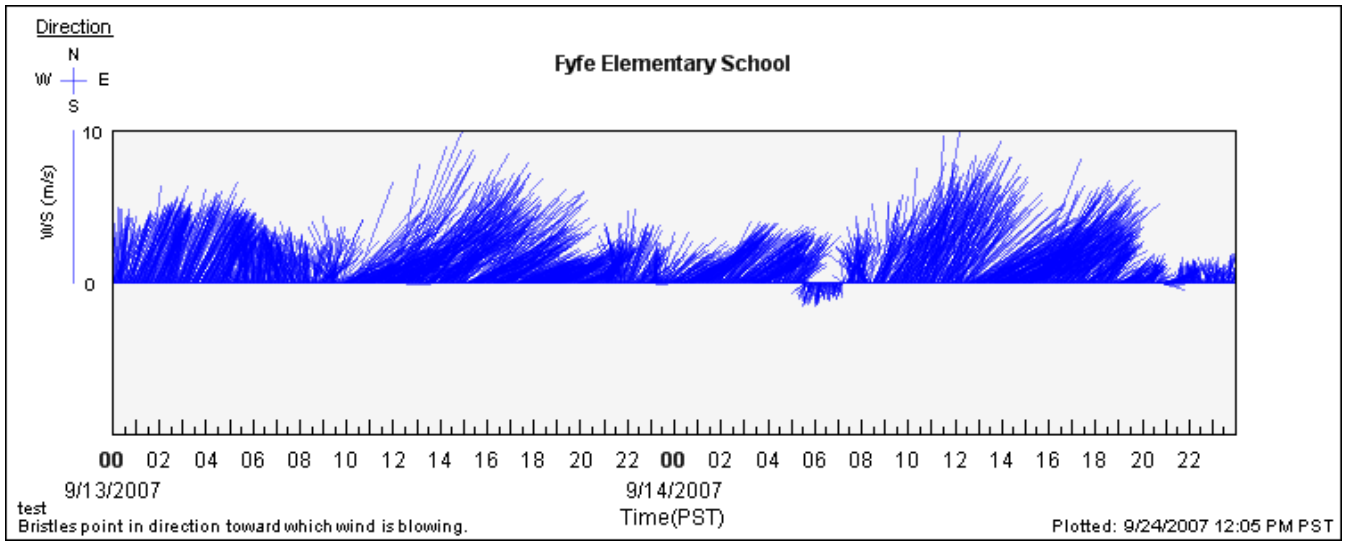




Note HVAC start time and different rate of ambient dilution vs. indoor dilution.

Example BC Time Series Showing Low BC Concentrations in Fyfe Classroom, Except When Door Left Open by the Teacher (After HVAC Changes)





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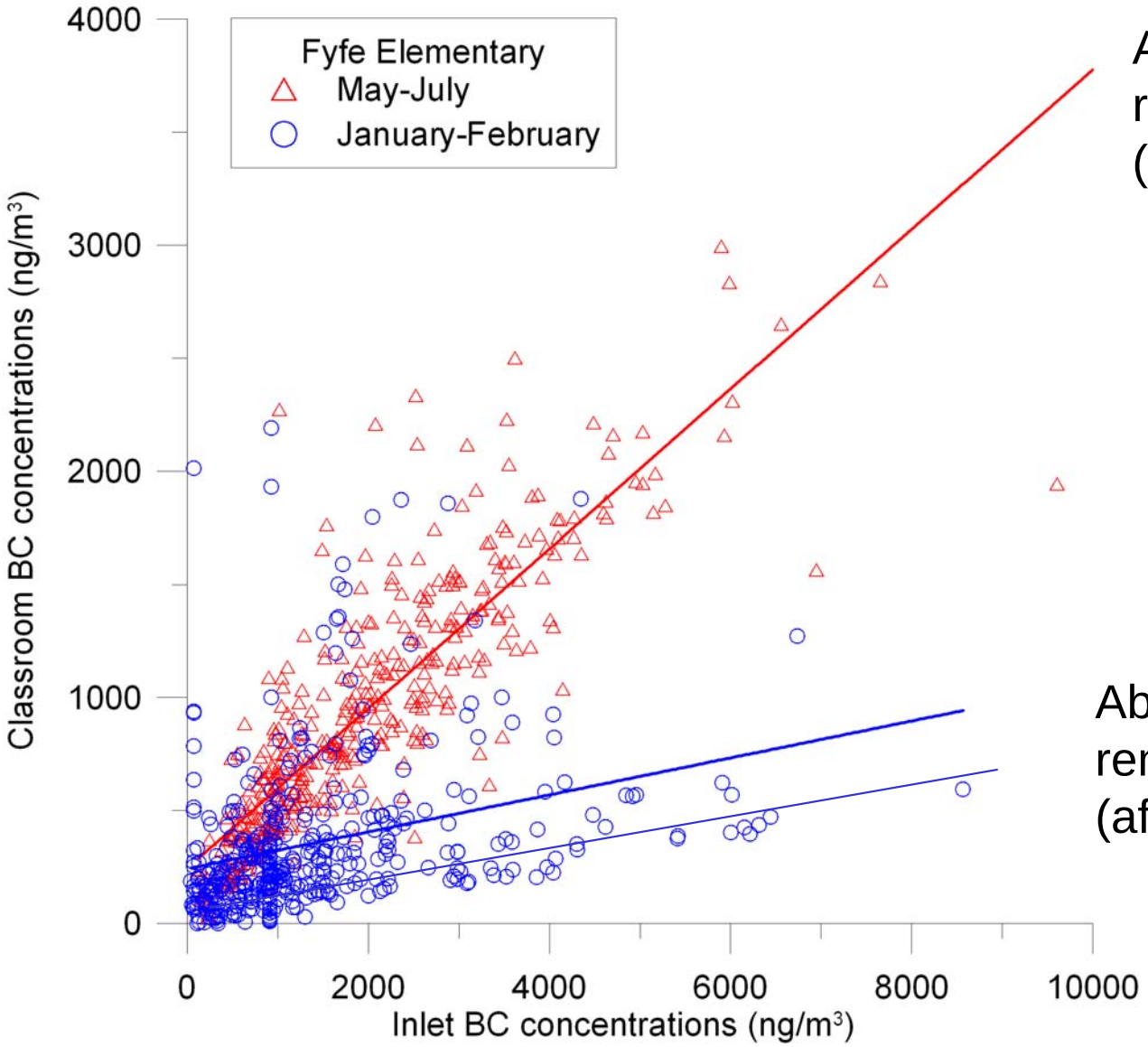
Indoor and Air Inlet BC Concentrations at Fyfe Before and After HVAC Changes



About 65% removal efficiency (before)

About 88% removal efficiency (after)

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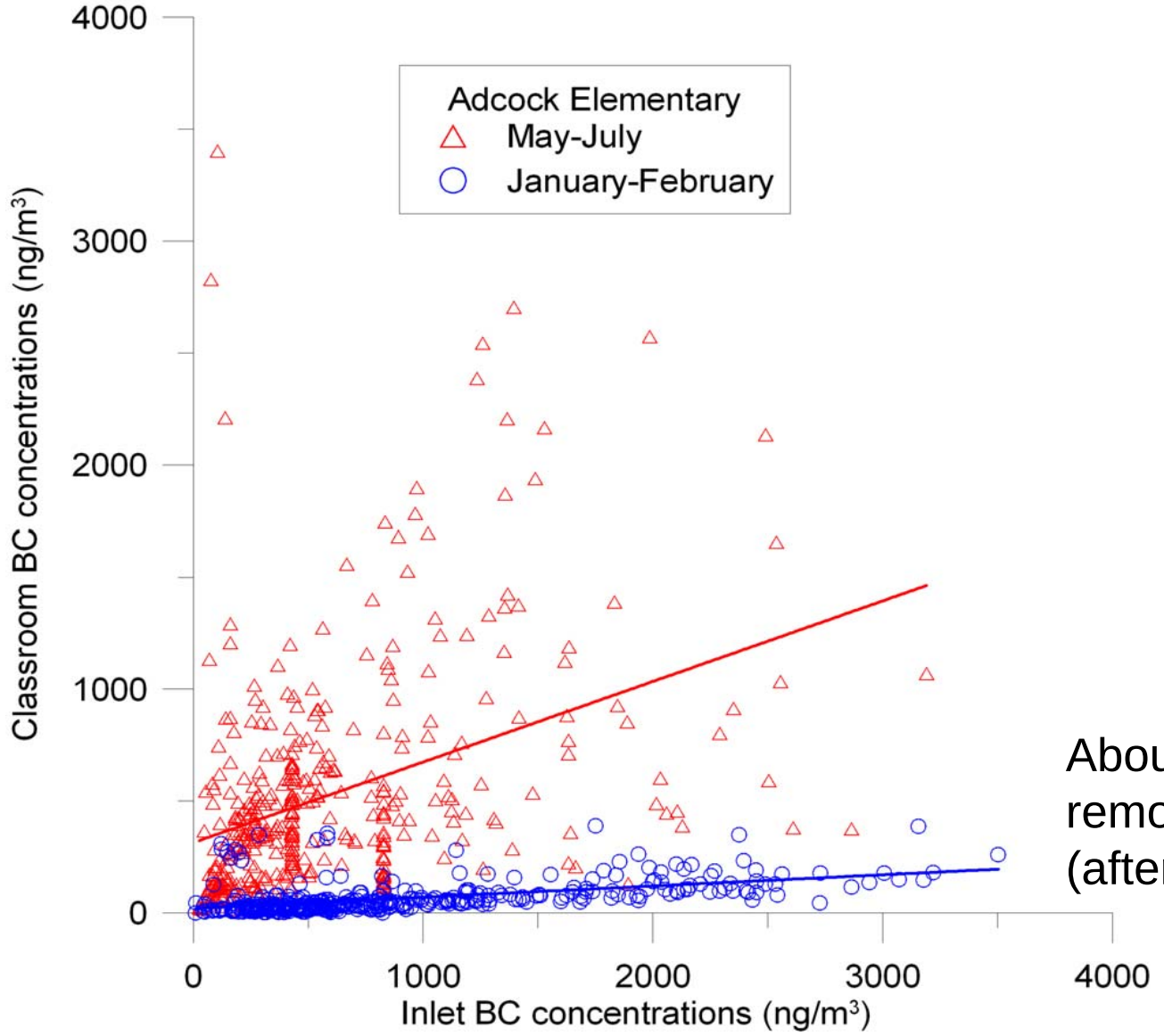
Indoor and Air Inlet BC Concentrations at Adcock Before and After HVAC Changes



About 94% removal efficiency (after)

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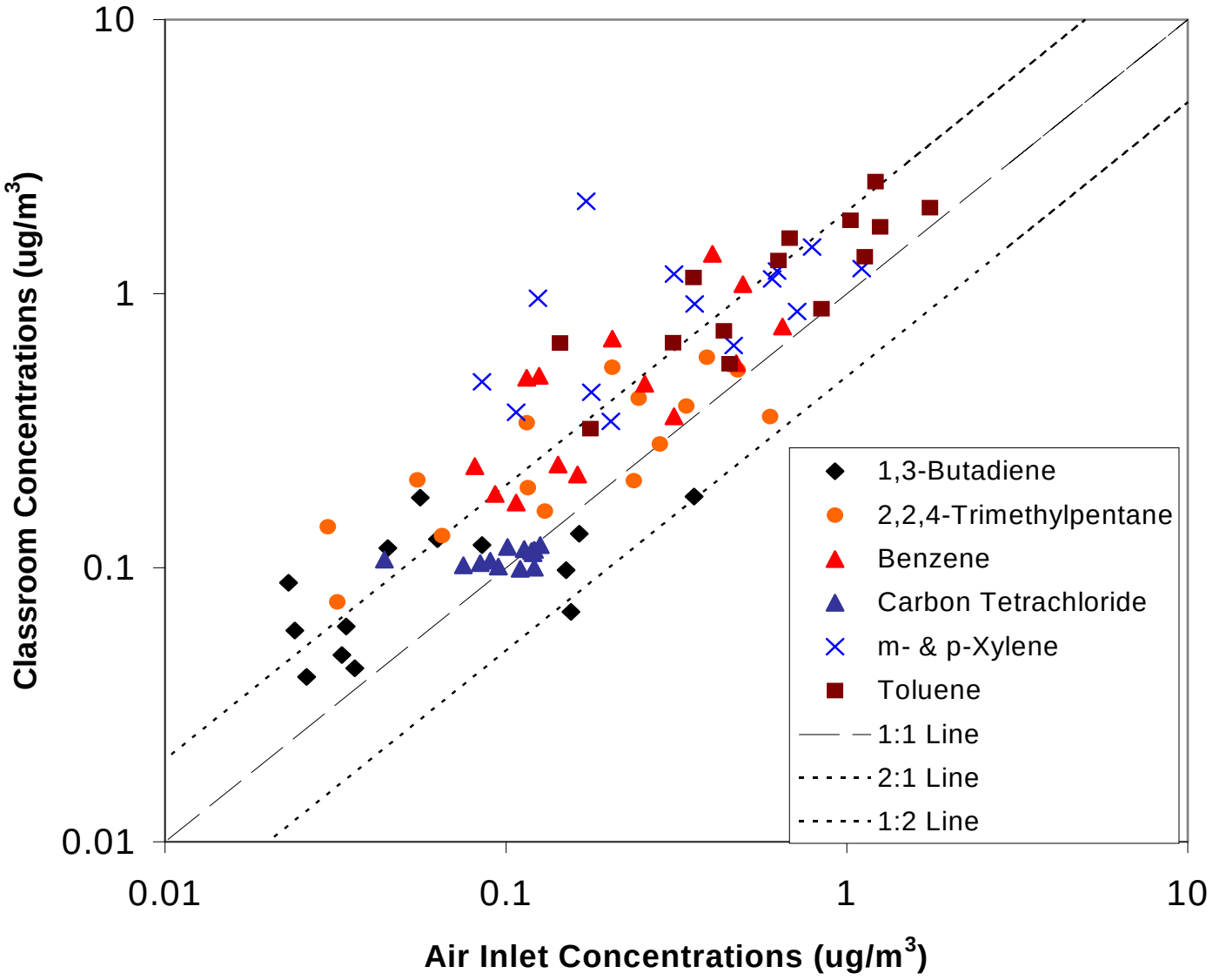
Indoor VOC Concentrations at Adcock (Summer) Higher than Outdoor for All Species Except CCl4



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Preliminary Summary of MSAT Filtration Characteristics

- Modest BC removal with existing HVAC systems in (summer).
- Significant BC removal with new HVAC filtration (winter).
- Adcock system removes more BC than Western or Fyfe.
- Indoor concentrations are often higher than outdoors for several gaseous MSATs (indoor sources or time lag in system?).

Mitigation Lessons Learned, So Far

- Typical HVAC operation can fill classroom with polluted air early in the morning which can result in higher concentrations indoors (than outdoors) later in morning.
- Leaving classroom doors open to outdoor hall can defeat filtration system.
- Diurnal pattern of pollution is an important consideration for exposure and mitigation (for both classroom and outdoors).

Acknowledgments

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Example of Winds in Benicia; 9/13/08 and 9/6/08 (KCABENIC3)