Black carbon: optical analysis of particle deposits and evaluation of daily personal exposure

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Overview

- What is black carbon?
- Major projects at the Kirchstetter Lab
- Summer assignments
  - Filter analysis for Cal Poly study
  - Personal exposure analysis using a microAethalometer

What is black carbon (BC)?

- Main component of soot; undesirable byproduct of combustion
- Positive climate forcing agent
  - Very efficient light-absorbing aerosol[1]
  - 2nd largest contributor to global warming[2]
  - Short atmospheric life time relative to other GHG
- Air pollutant, concern for human health
  - Respiratory irritant and possible carcinogen[3]

[1] Kirchstetter, T.W., T. Novakov, and P.V. Hobbs (2004). Evidence that the spectral dependence of light absorption by aerosols is affected by organic carbon. *Journal of Geophysical Research, 109.*

[2] Ramanathan, V. and G. Carmichael (2008). Global and regional climate changes due to black carbon. *Nature Geoscience, 1, 221-227.*

[3] Air Resources Board, California Environmental Protection Agency (2010). "Health Effects of Diesel Exhaust Particulate Matter". Accessed 13 August 2010. <http://www.arb.ca.gov/research/diesel/dpm_health_fs.pdf>.

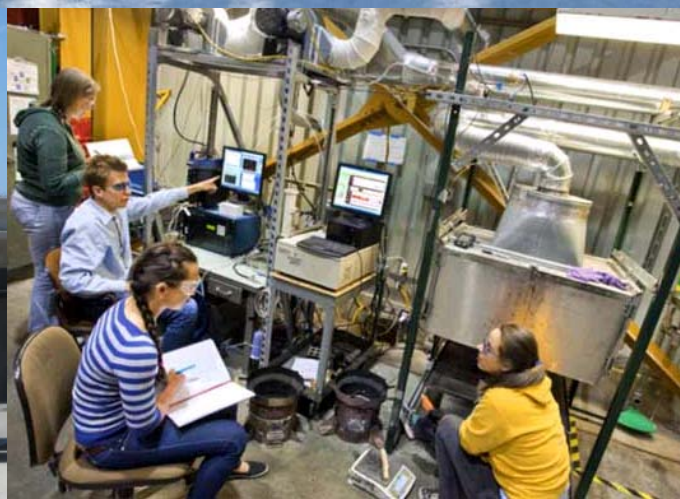
What is black carbon (BC)?

- Major sources
  - Fuel combustion
    - Motor vehicles, particularly diesel engines
    - Coal
  - Biomass burning
    - Cooking
    - Deforestation, slash & burn technique

Ramanathan, V. and G. Carmichael (2008). Global and regional climate changes due to black carbon. *Nature Geoscience, 1: 221-227.*

Major projects at the Kirchstetter Lab during summer 2010

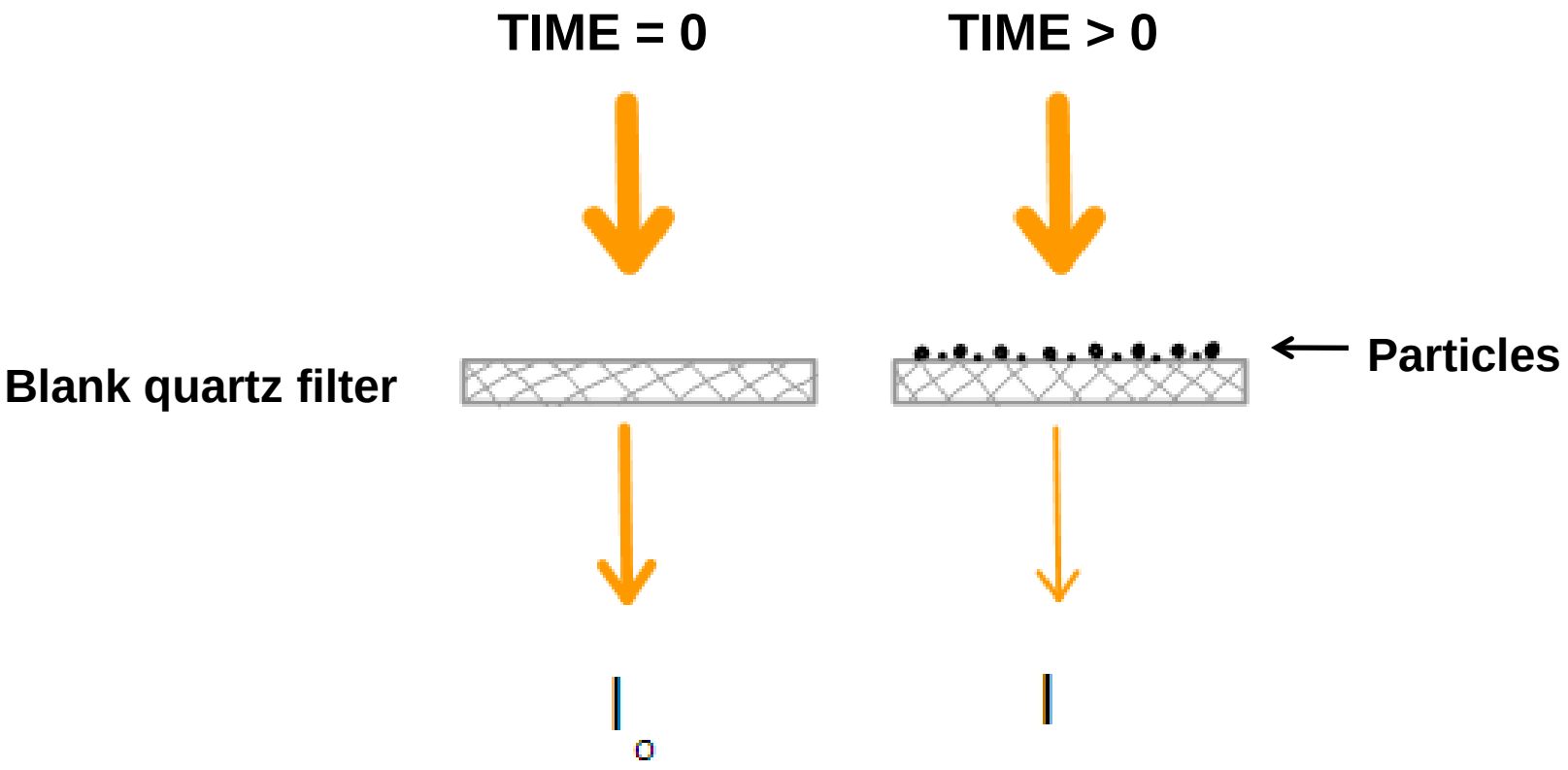
- Motor-vehicle emissions
  - Caldecott Tunnel
  - Port of Oakland
- Cook stove emissions
- Snow and albedo changes



Summer assignments

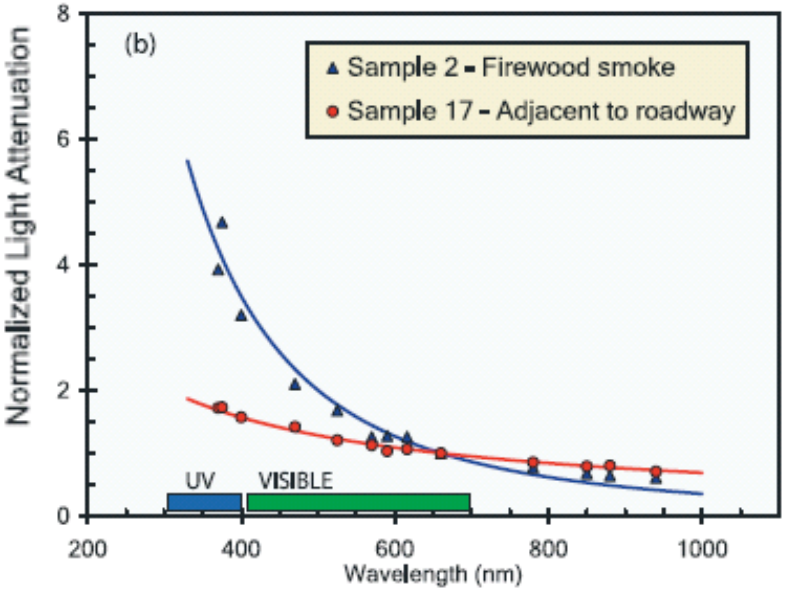
- Filter analysis with spectrometer for Cal Poly study
- Personal exposure to black carbon using microAethalometer

Collecting and measuring light-absorbing particles



Measuring BC concentrations and aerosol optical properties

- Aethalometer measures BC in ambient air
  - Loads particles on internal filter paper, BC = ATN_{880}/σ
- Light-absorbing organic carbon (OC) has greater spectral dependence; larger absorption at near UV wavelengths



- Measure of spectral dependence = Angstrom Absorption Exponent (AAE)
  - $ATN_\lambda \alpha \lambda^{-AAE}$
    - AAE~1, filter deposit is mainly BC
    - AAE>1, light-absorbing OC particles

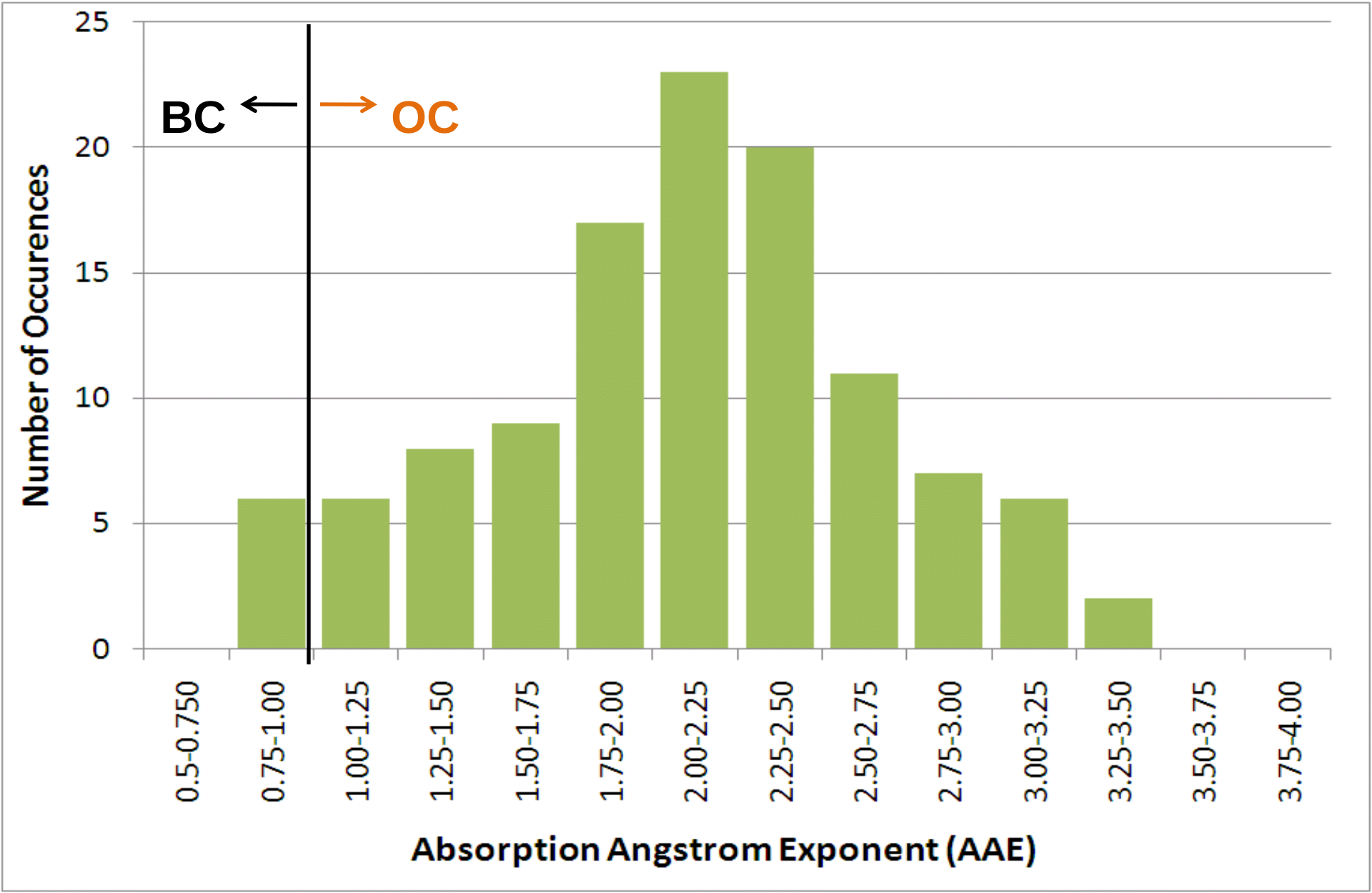
Kirchstetter, T.W., T. Novakov, and P.V. Hobbs (2004). Evidence that the spectral dependence of light absorption by aerosols is affected by organic carbon. *Journal of Geophysical Research, 109.*

Cal Poly study

- Wood smoke emissions and local air quality in residential areas
  - Wood combustion is usually major contributor to PM concentrations during winter months
- 16 locations within Cambria, CA neighborhood
  - Quartz filters collected over 12-hour evening periods
    - Analyzed with spectrometer for AAE values
  - Aethalometers collected time-resolved data

Distribution of AAE for all 2010 filters, n_{loaded}=115

575-360nm



Cal Poly study

- Main lesson learned: importance of instrument calibration
- Performed tests to ensure spectrometer was operating properly
  - Made adjustments to reduce variability of data
  - Tested instrument frequently throughout optical analysis of filters

Personal exposure to black carbon

- Government monitoring at fixed locations may not represent individual exposures to air pollutants
  - Solution = carrying around a portable monitoring device
- Lack of personal exposure data set for black carbon

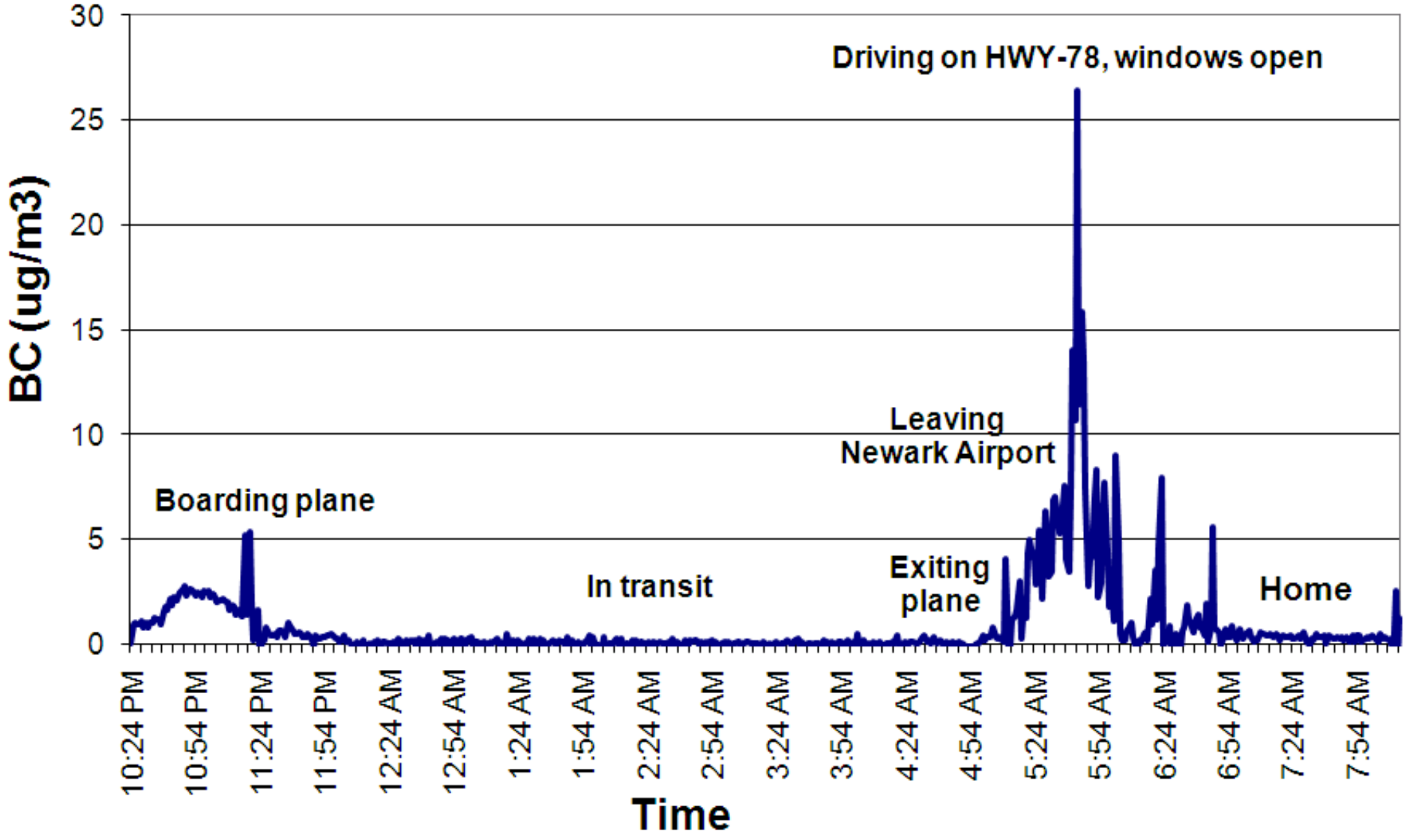
Personal exposure to black carbon

- Device used: Magee Scientific microAeth Model AE51
  - Portable aethalometer to measure black carbon concentrations in ambient air
  - Fits easily in backpack, purse, pocket, etc.

Photo: http://mageesci.com/products/microaeth_AE51.htm

Personal exposure to black carbon

- Method
  - Carried device though out daily routine
  - BC concentrations collected every second
  - Recorded time and location to match BC concentration peaks with certain places and activities
  - Examples of locations/activities
    - Air travel from San Francisco to New Jersey
    - Daily commute to LBL
    - Walking around downtown Berkeley and San Francisco


July 14-15, 2010 - Travel from SFO to NJ
microAethalometer raw data : 1-min average
BC (ug/m3)
30
25
20
15
10
5
0
Driving on HWY-78, windows open
Leaving
Newark Airport
Boarding plane
In transit
Exiting
plane
Home
10:24 PM
10:54 PM
11:24 PM
11:54 PM
12:24 AM
12:54 AM
1:24 AM
1:54 AM
2:24 AM
2:54 AM
3:24 AM
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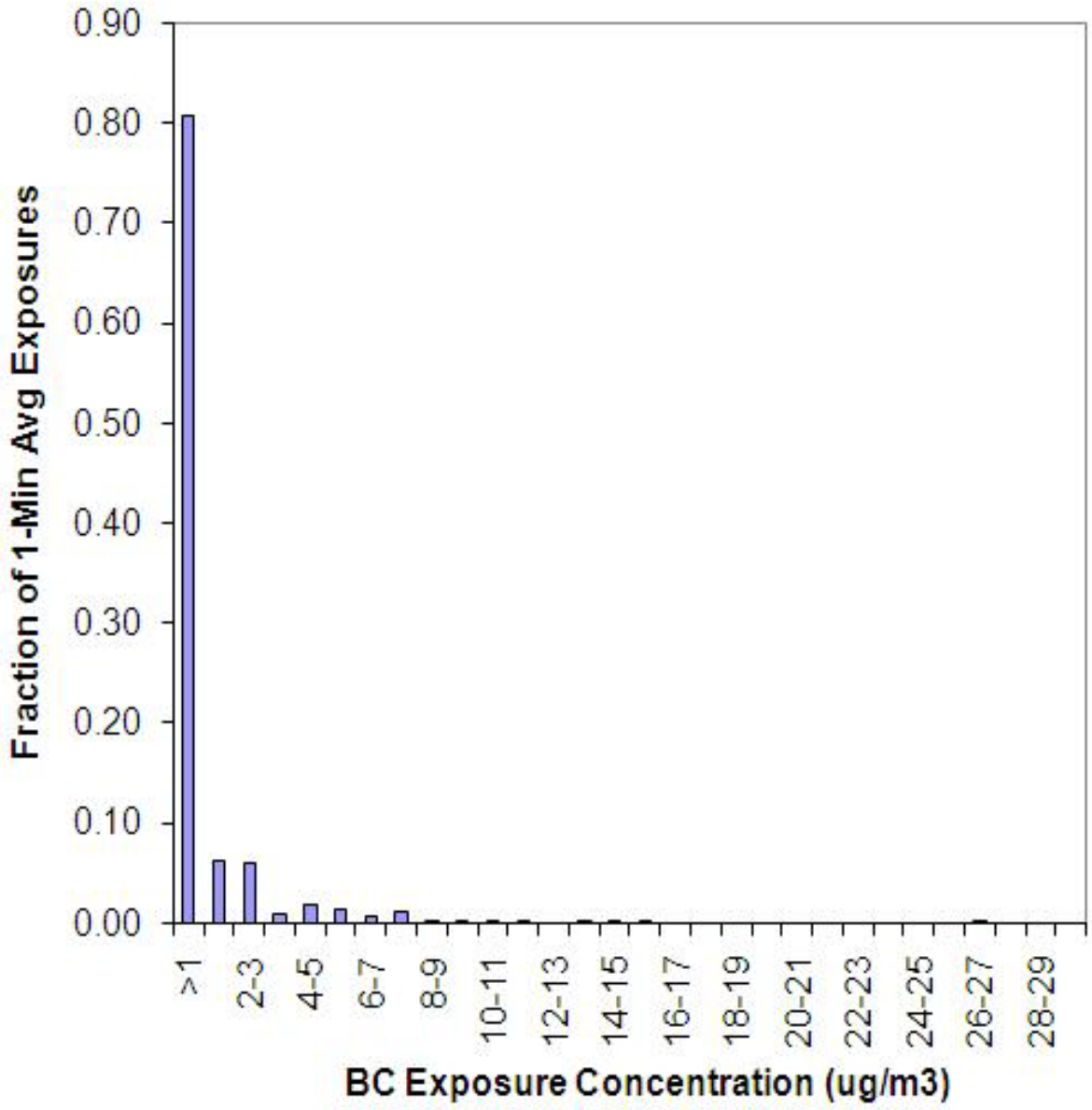
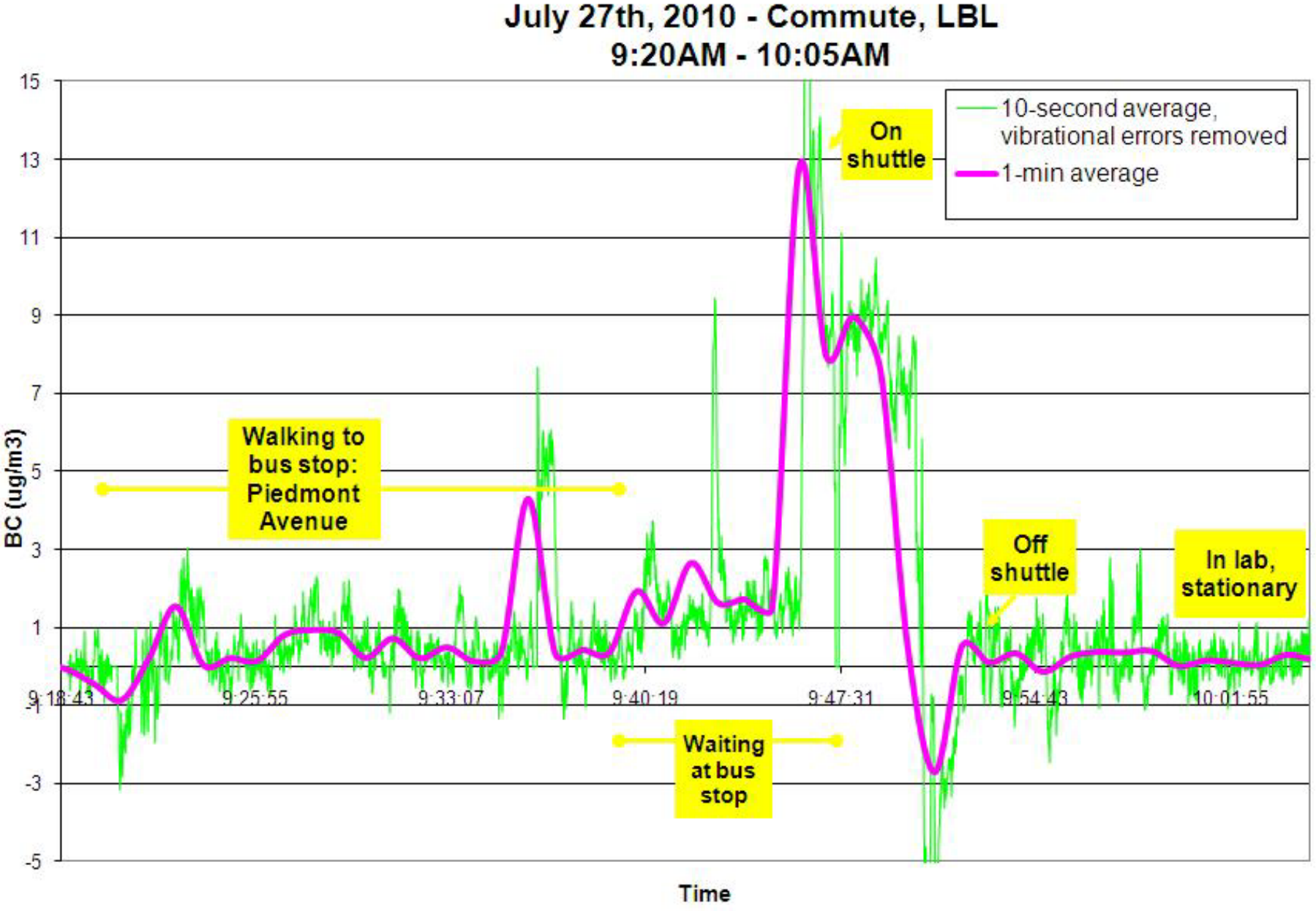
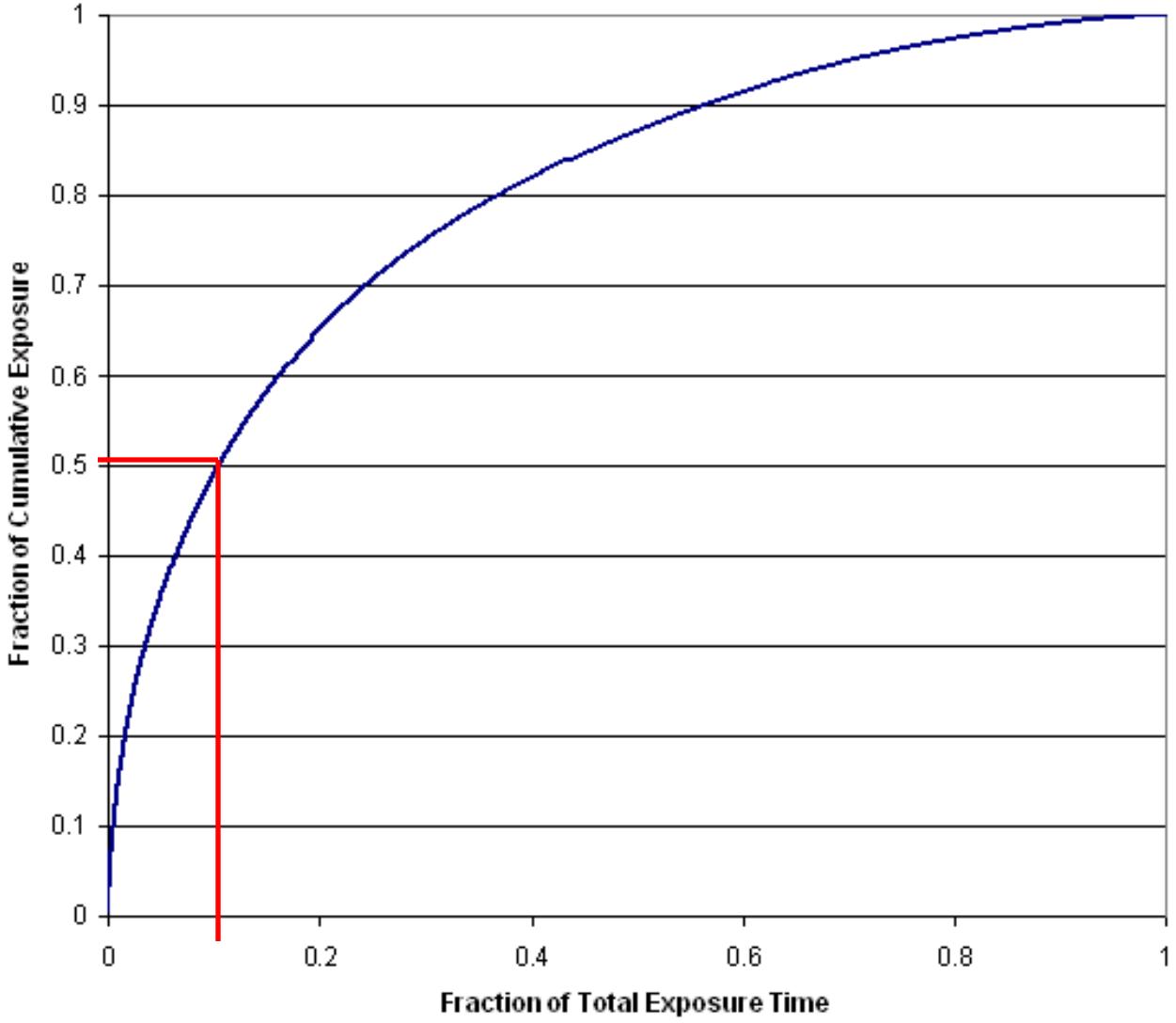
5:54 AM
6:24 AM
6:54 AM
7:24 AM
7:54 AM
Time


July 14-15, 2010 - Travel: CA to NJ
Fraction of 1-Min Avg Exposures
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
>1
2-3
4-5
6-7
8-9
10-11
12-13
14-15
16-17
18-19
20-21
22-23
24-25
26-27
28-29
BC Exposure Concentration (ug/m3)


July 27th, 2010 - Commute, LBL
9:20AM - 10:05AM
10-second average, vibrational errors removed
1-min average
On shuttle
Walking to bus stop: Piedmont Avenue
Waiting at bus stop
Off shuttle
In lab, stationary
BC (ug/m3)
Time
15
13
11
9
7
5
3
1
-1
-3
-5
9:18:43
9:25:55
9:33:07
9:40:19
9:47:31
9:54:43
10:01:55

Cumulative Exposure

July 22nd – August 5th, 2010

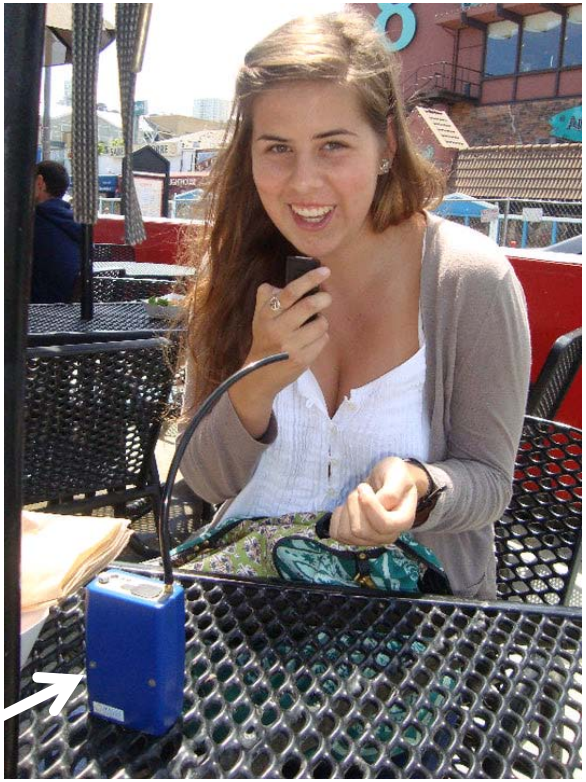


Conclusions

- For days with large peaks in BC exposure, majority of cumulative exposure occurs over short periods of time
  - If these exposures are eliminated, daily BC exposure could be quickly reduced
- Peaks in exposure generally correlate to activities involving vehicles or other sources of combustion
  - For example, driving with the windows open or walking along a busy street

Future studies

- Continuing personal exposure study with microAeth into the fall 2010 semester



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Questions?