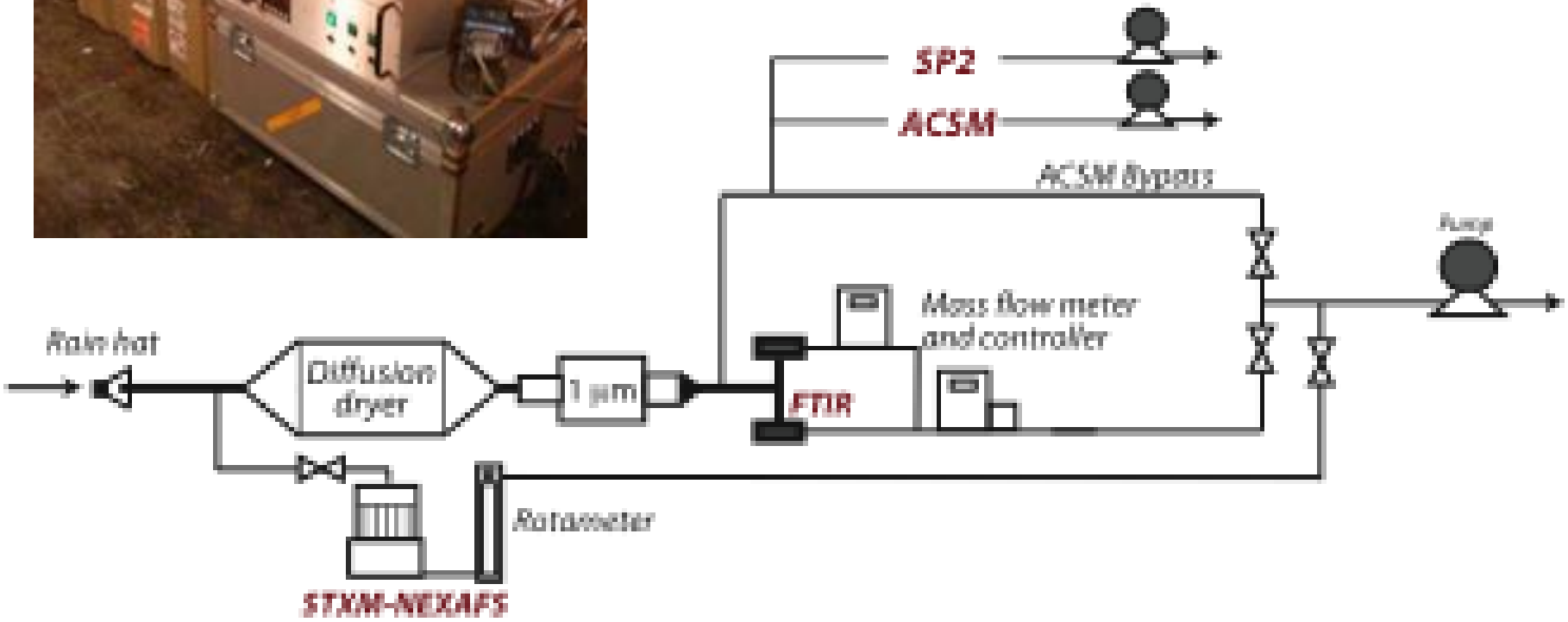
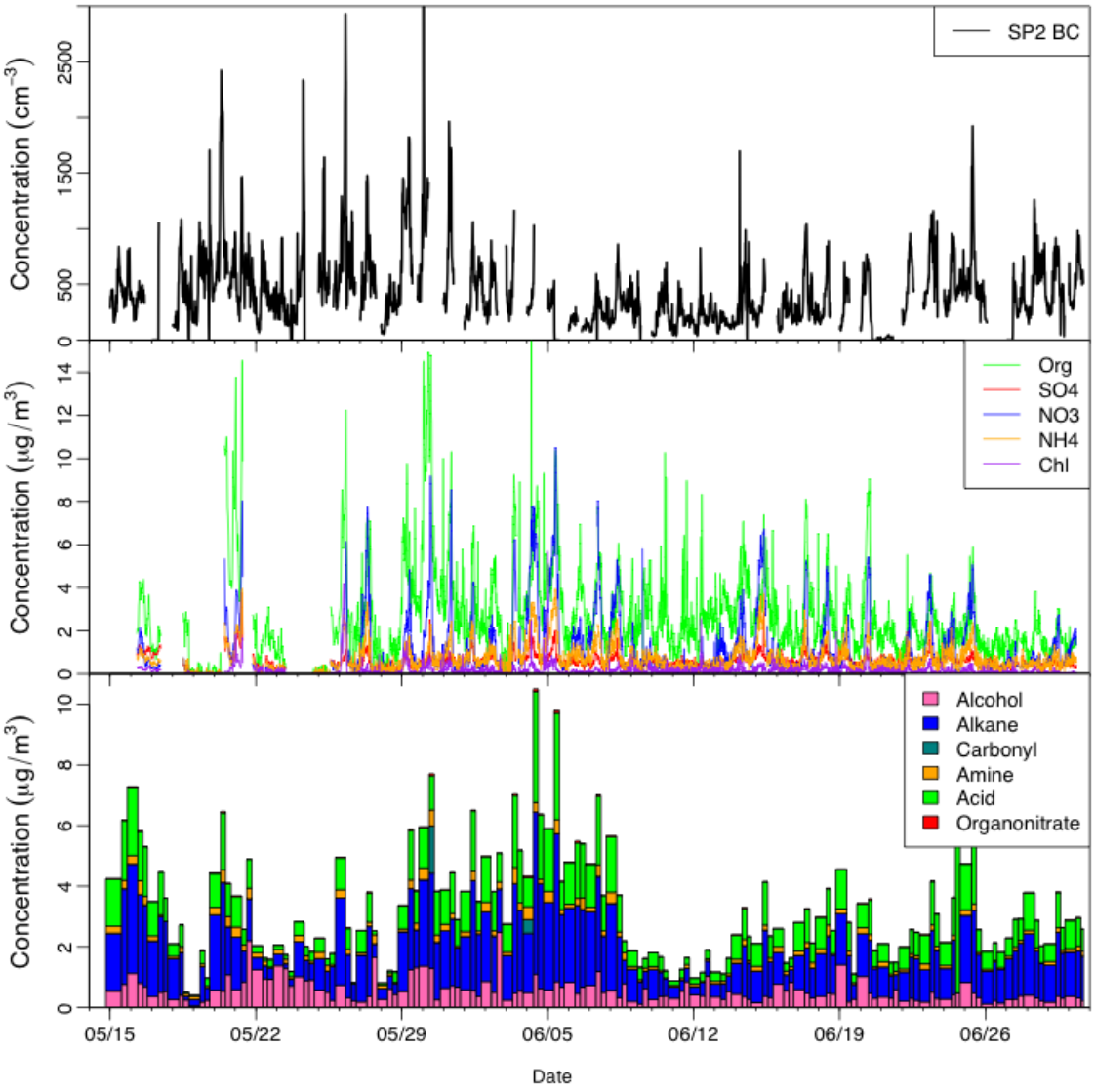
Temporal variations of aerosol components in Tijuana, Mexico, during the Cal-Mex campaign

S. Takahama, A. Johnson, J. Guzman Morales, L.M. Russell
Scripps Institution of Oceanography, University of California San Diego
R. Duran, A. Cortez, B. Puckita, G. Rodríguez
Universidad de Autónoma de Baja California, Tijuana
R. Subramanian
Droplet Measurement Technologies, Inc.
D. Toom-Sauntry, R. Leaitch
Science & Technology Branch, Environment Canada

Measurement of submicron aerosol composition and concentrations in Tijuana, Mexico



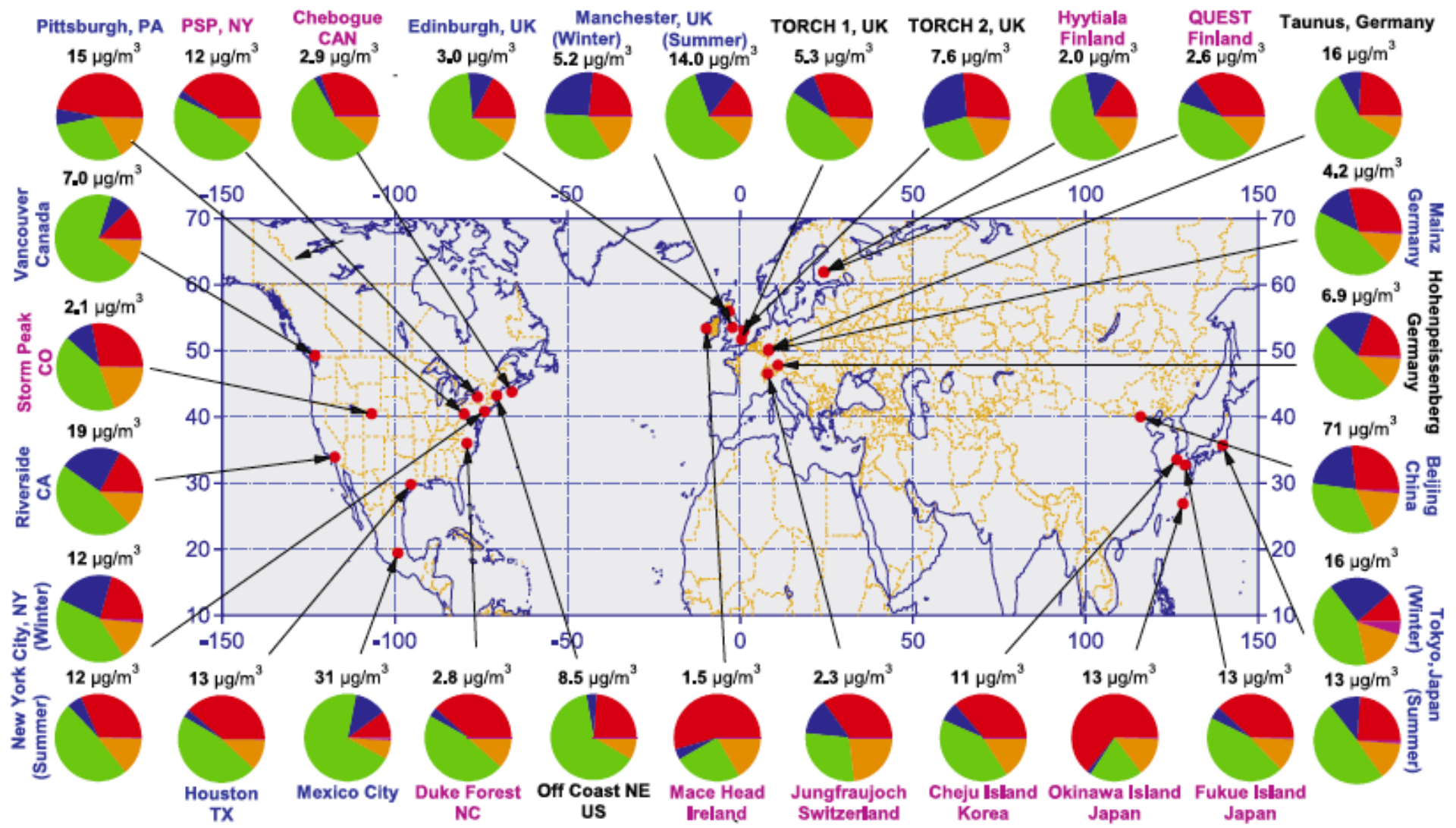
Measurements of BC, organic, and NR inorganic aerosol



Instrument: Single Particle Soot Photometer (SP2)
Measures: black carbon mass and number
Time resolution: single particle

Instrument: Aerosol Chemical Speciation Monitor (ACSM)
Measures: submicron non-refractory inorganic ion and organic molecular fragment concentrations
Time resolution: 15-30 min

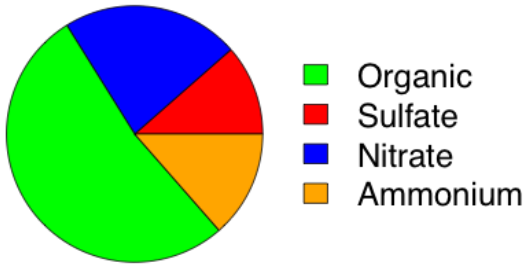
Instrument: Fourier Transform Infrared Spectroscopy (FTIR)
Measures: submicron organic functional group concentrations
Time resolution: 6-12 hours



Zhang et al., 2007

Tijuana: 4.0 µg/m^3

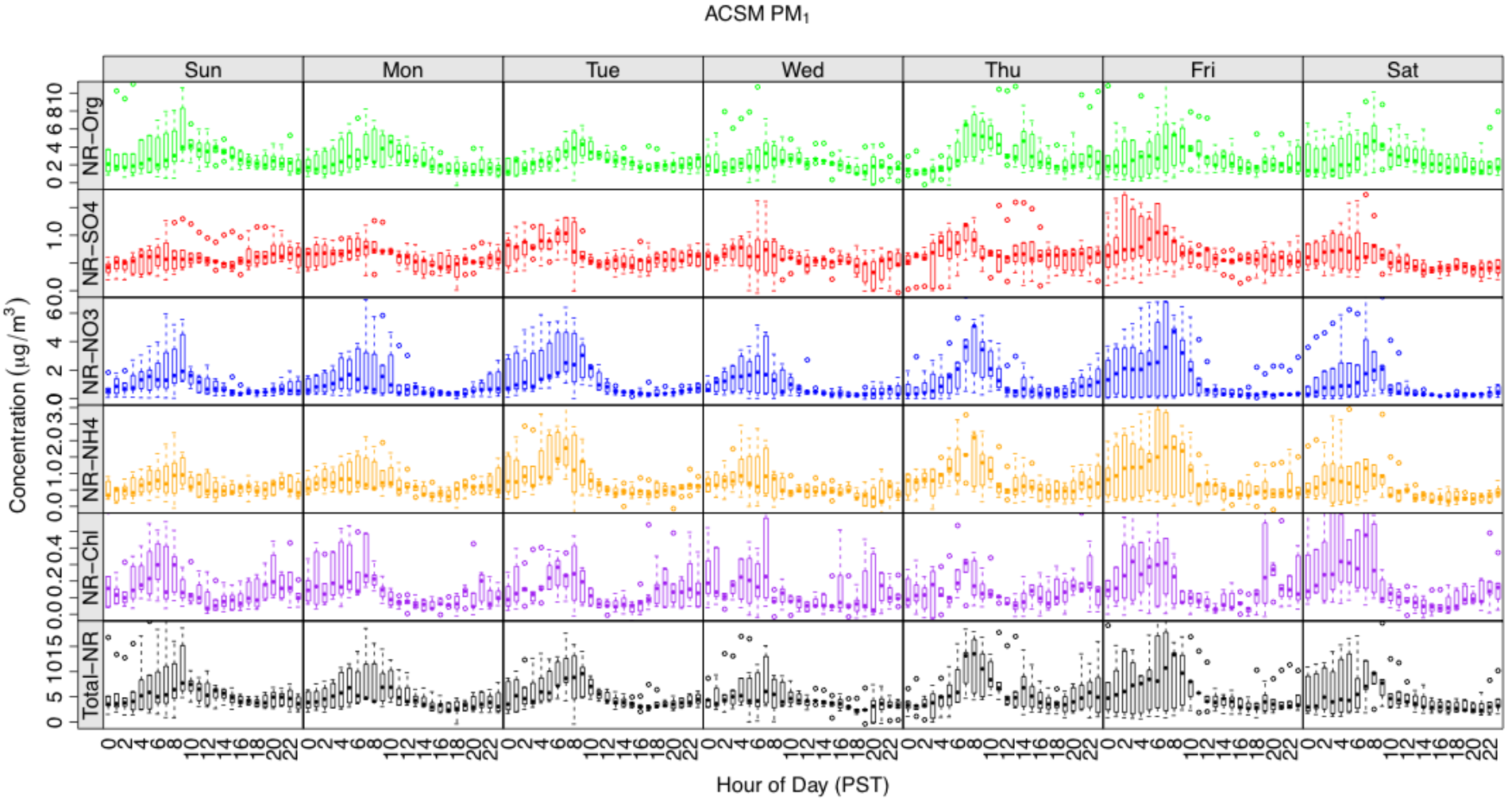
May 15 - June 30



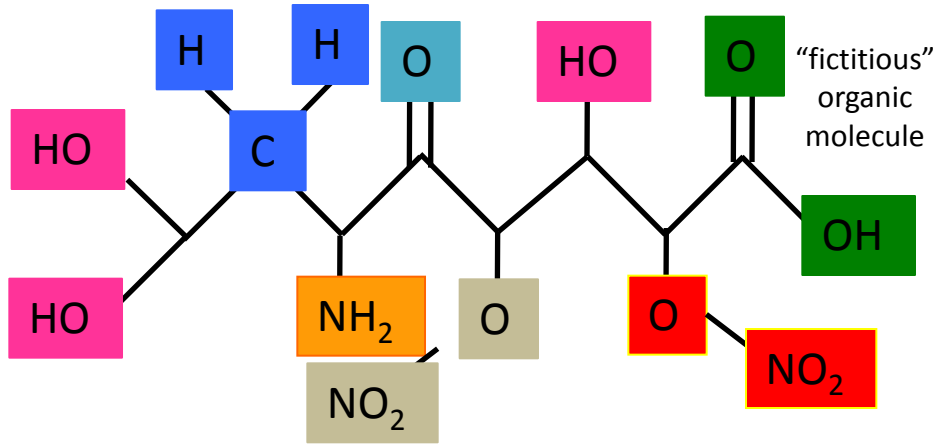
- NR-PM_1 Composition similar to S. California

Temporal variations in non-refractory PM_1

(Parque Morelos, May 15-June 30, ACSM)



Organic Functional Groups by FTIR



Carboxylic Acid (COOH)

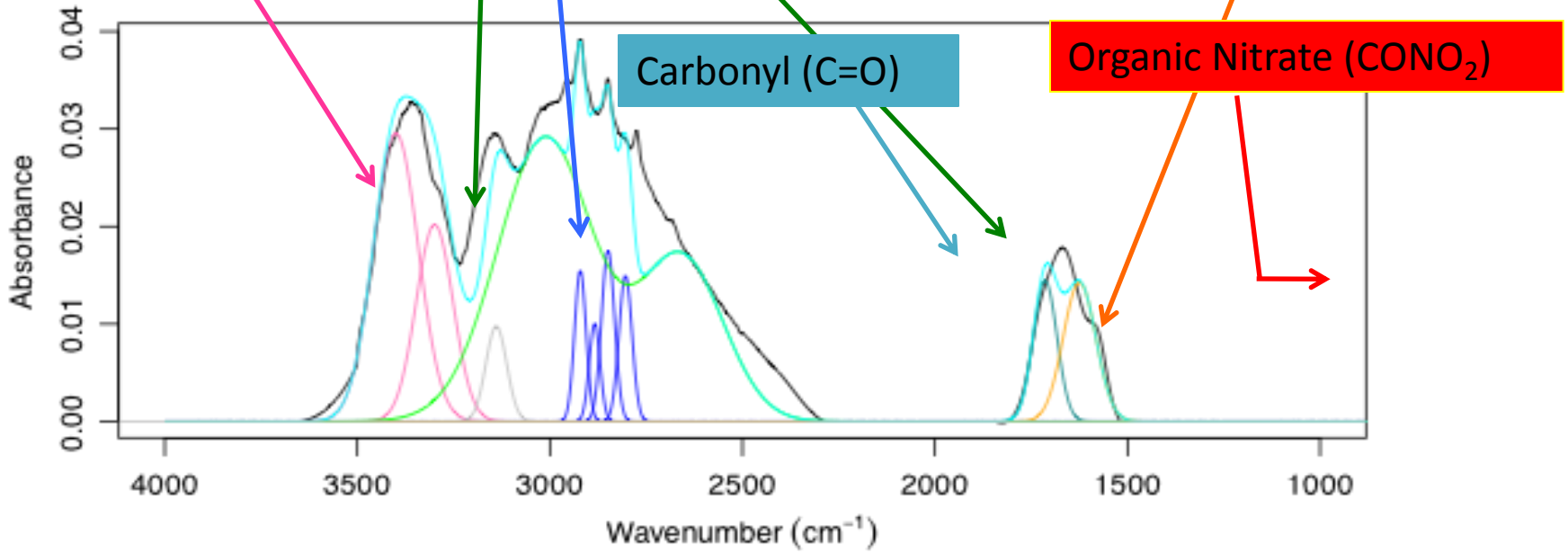
Organic hydroxyl or alcohol (COH)

Alkane and alkene (C-CH, C=C-H)

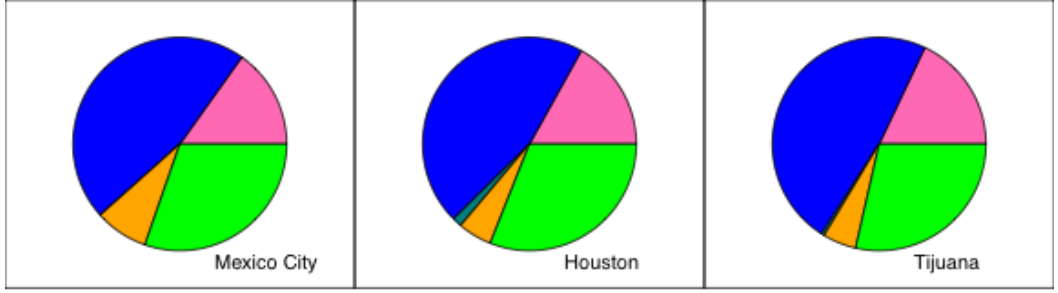
Primary Amine (CNH_2)

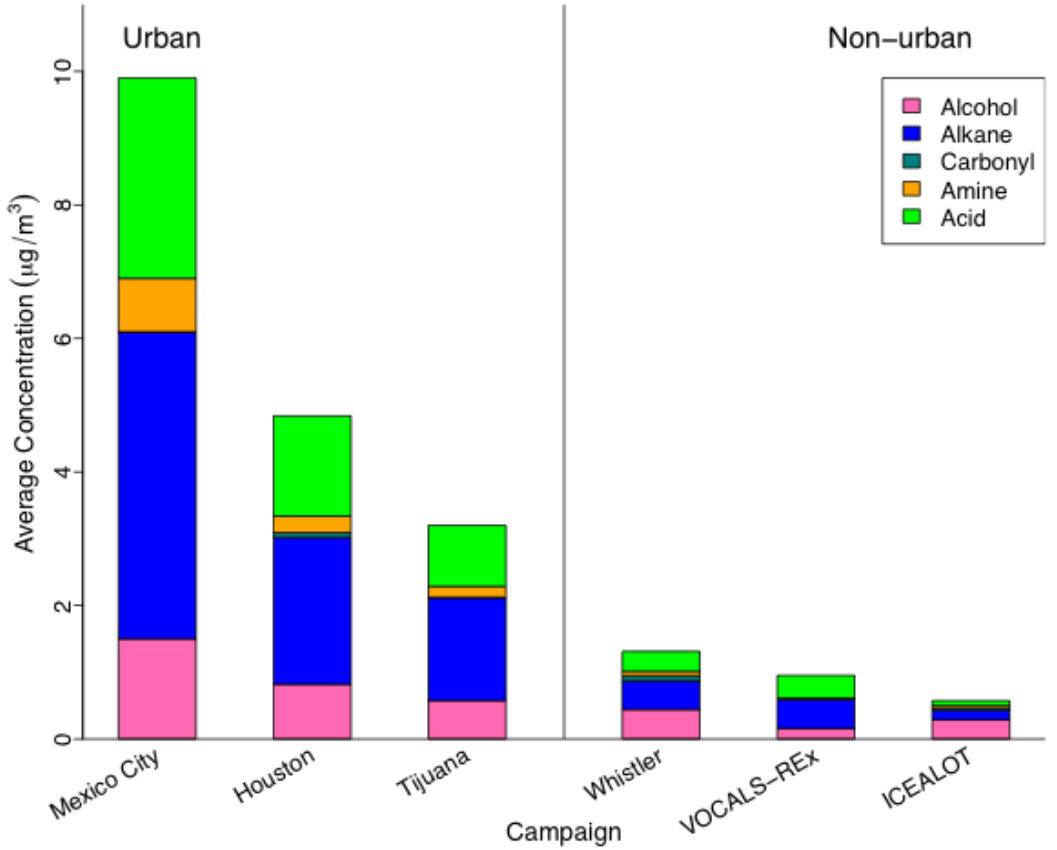
Carbonyl (C=O)

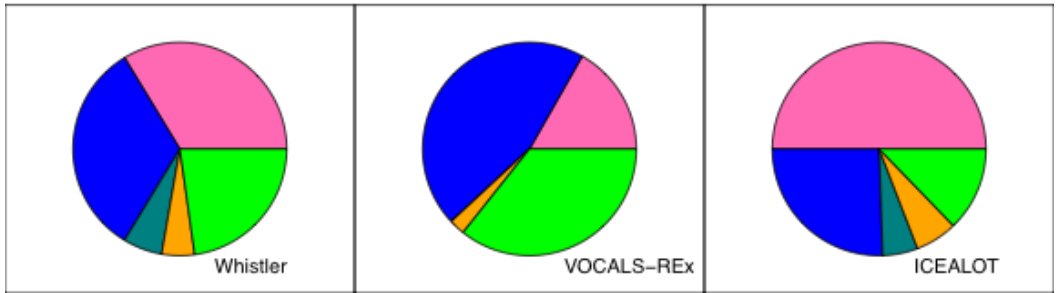
Organic Nitrate ($CONO_2$)



- Peak area is proportional to the moles of bond on the sample filter.
- Proportionality constant varies with each functional group and is calibrated in the laboratory.



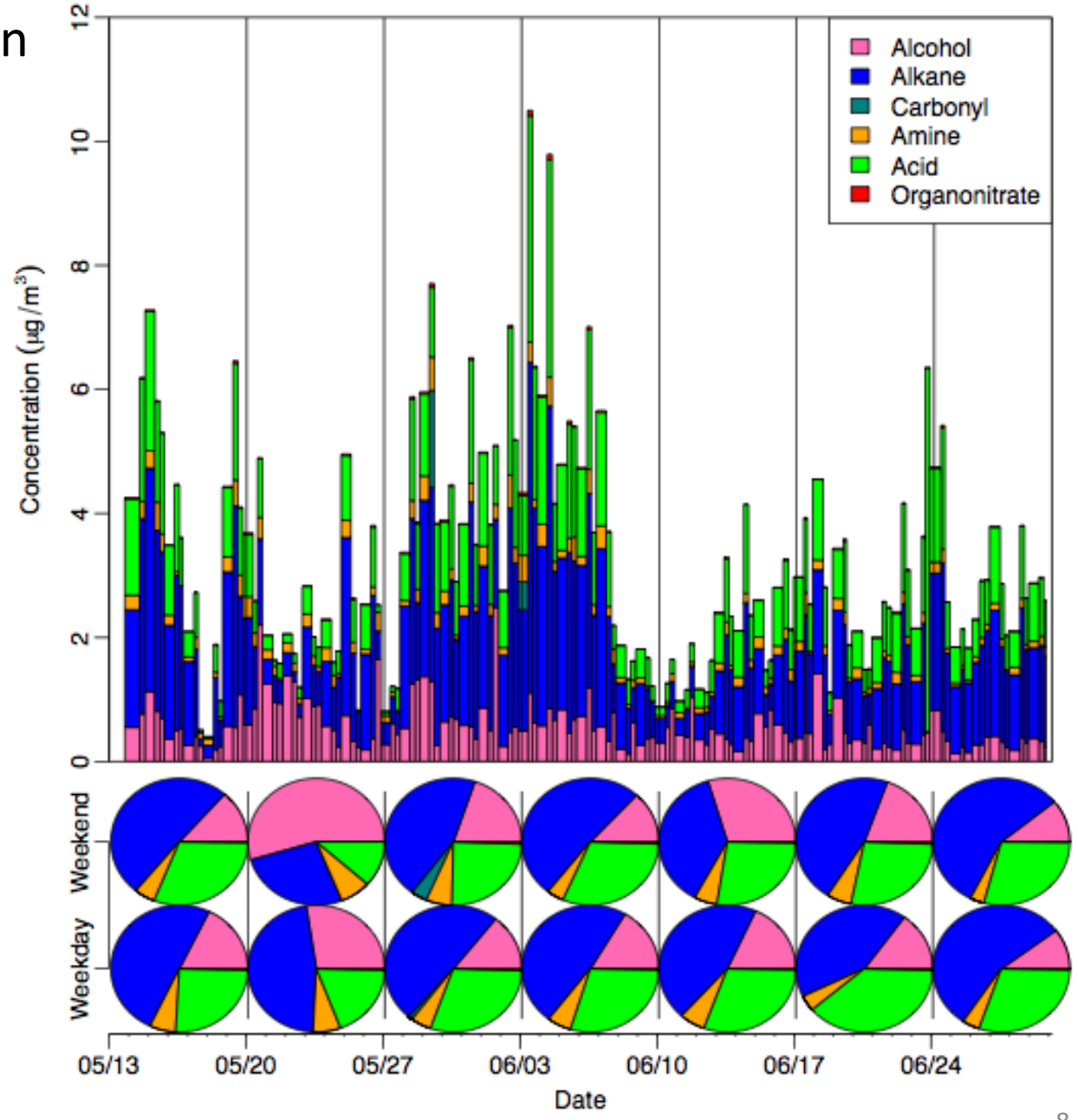


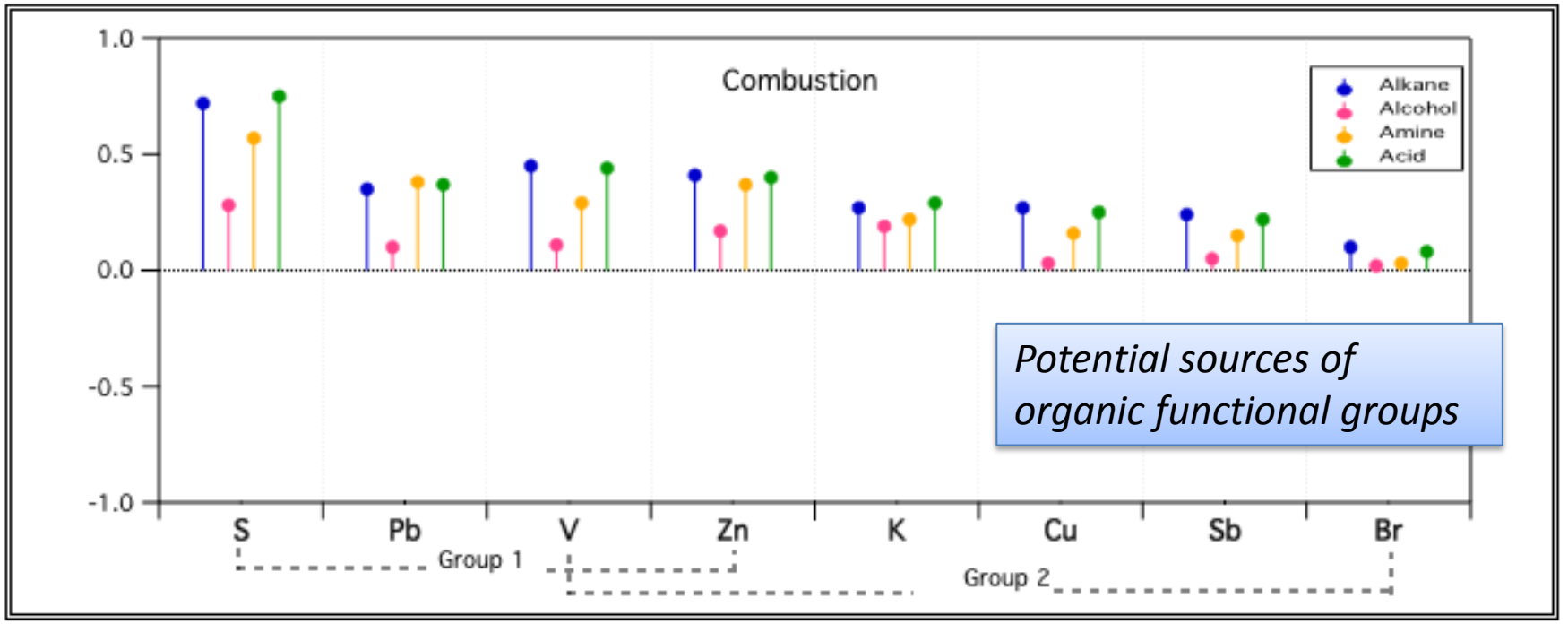


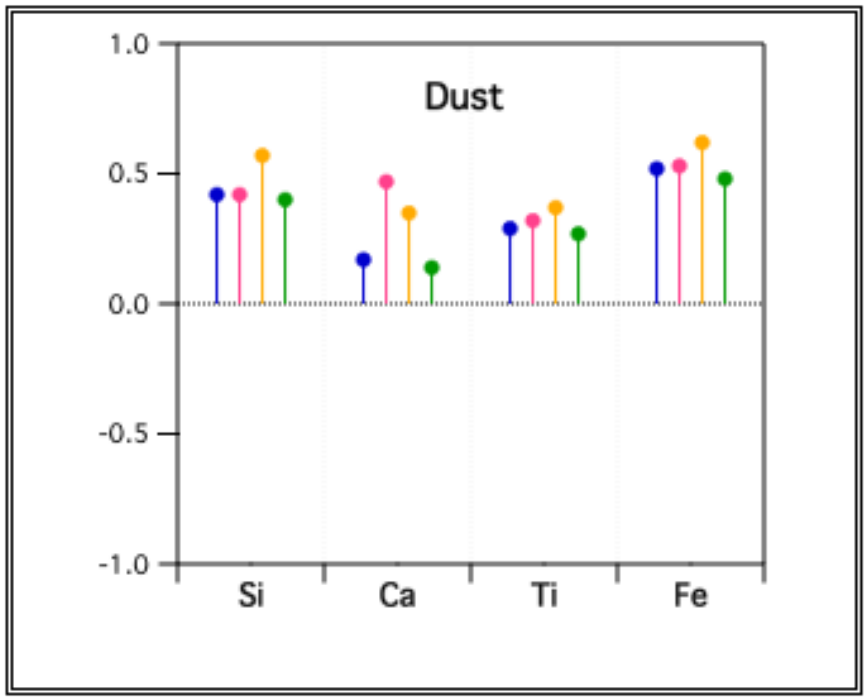
- Functional group composition in Tijuana resembles composition observed in other urban areas.
- Distinctly different from average composition of samples collected in non-urban areas.

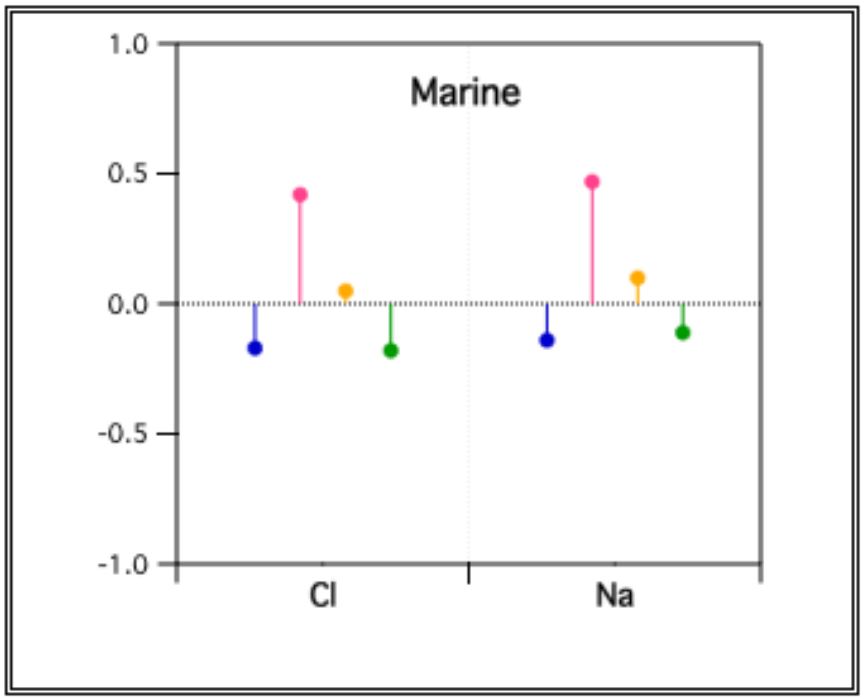
Weekly variations in functional group composition

- Generally uniform composition throughout, except during low-concentration periods.
- Weekday and weekend composition is similar with a few exceptions.

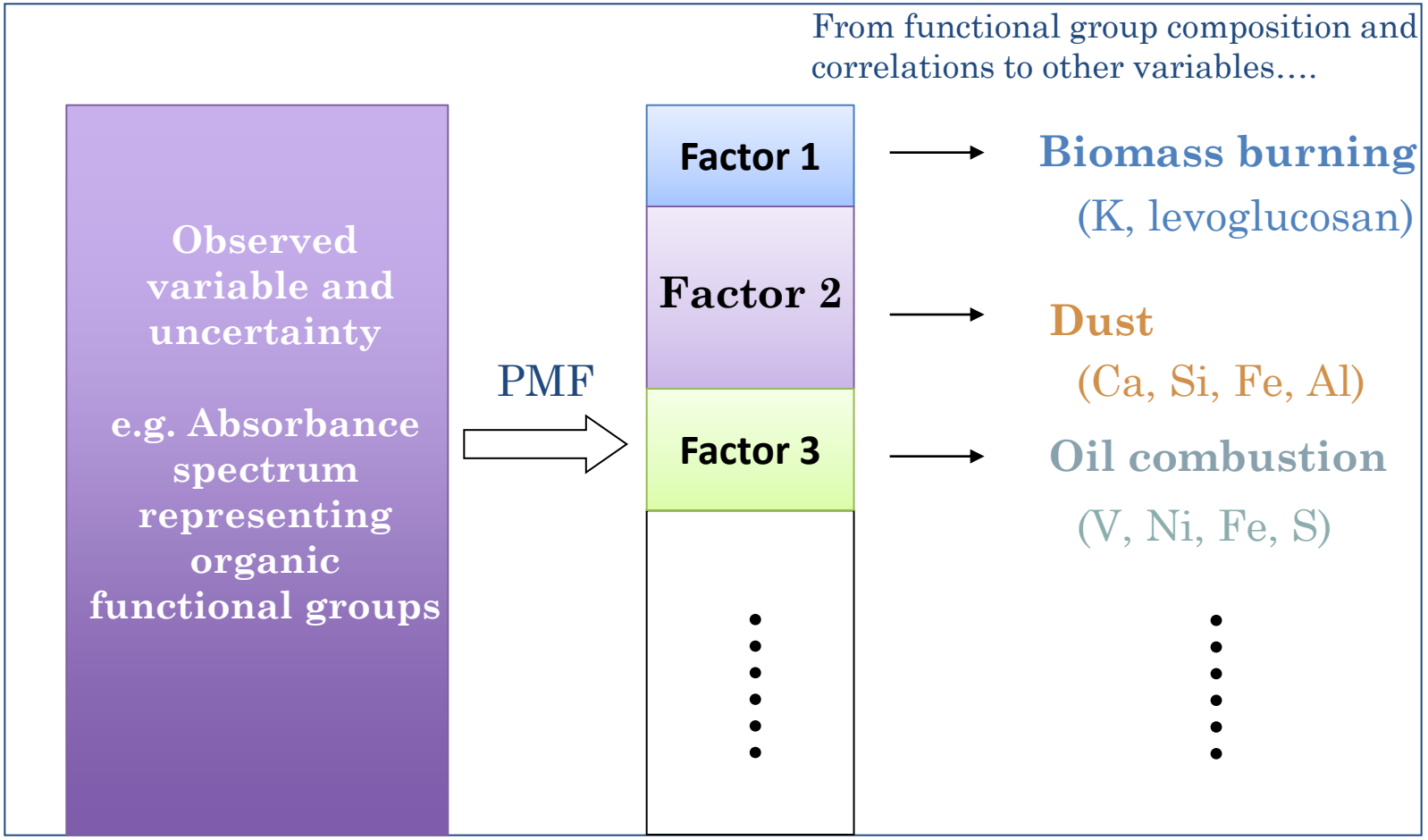



Combustion
Alkane
Alcohol
Amine
Acid
1.0
0.5
0.0
-0.5
-1.0
S
Pb
V
Zn
K
Cu
Sb
Br
Group 1
Group 2
Potential sources of organic functional groups

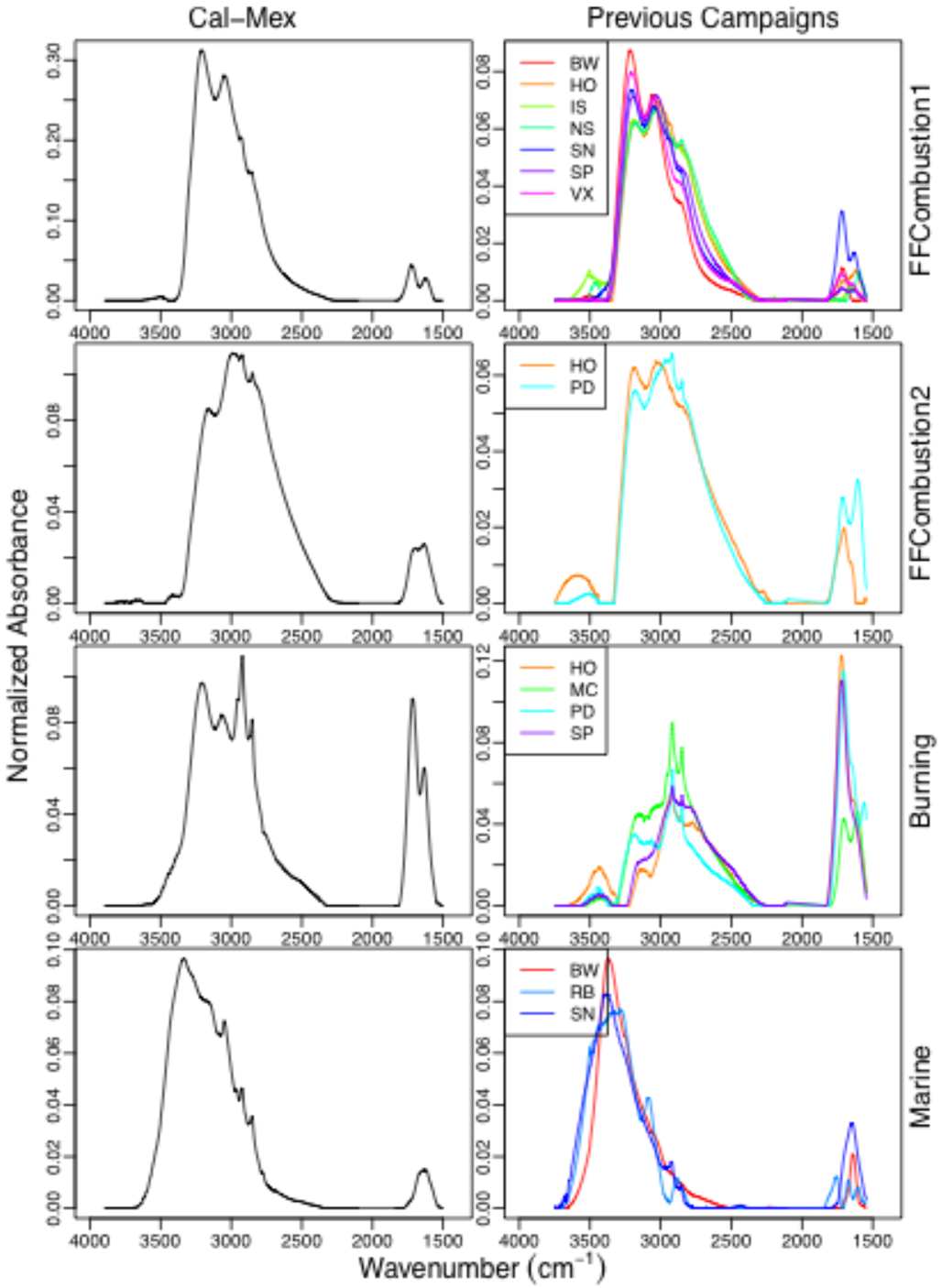

Dust
1.0
0.5
0.0
-0.5
-1.0
Si
Ca
Ti
Fe


Marine
1.0
0.5
0.0
-0.5
-1.0
Cl
Na

POSITIVE MATRIX FACTORIZATION



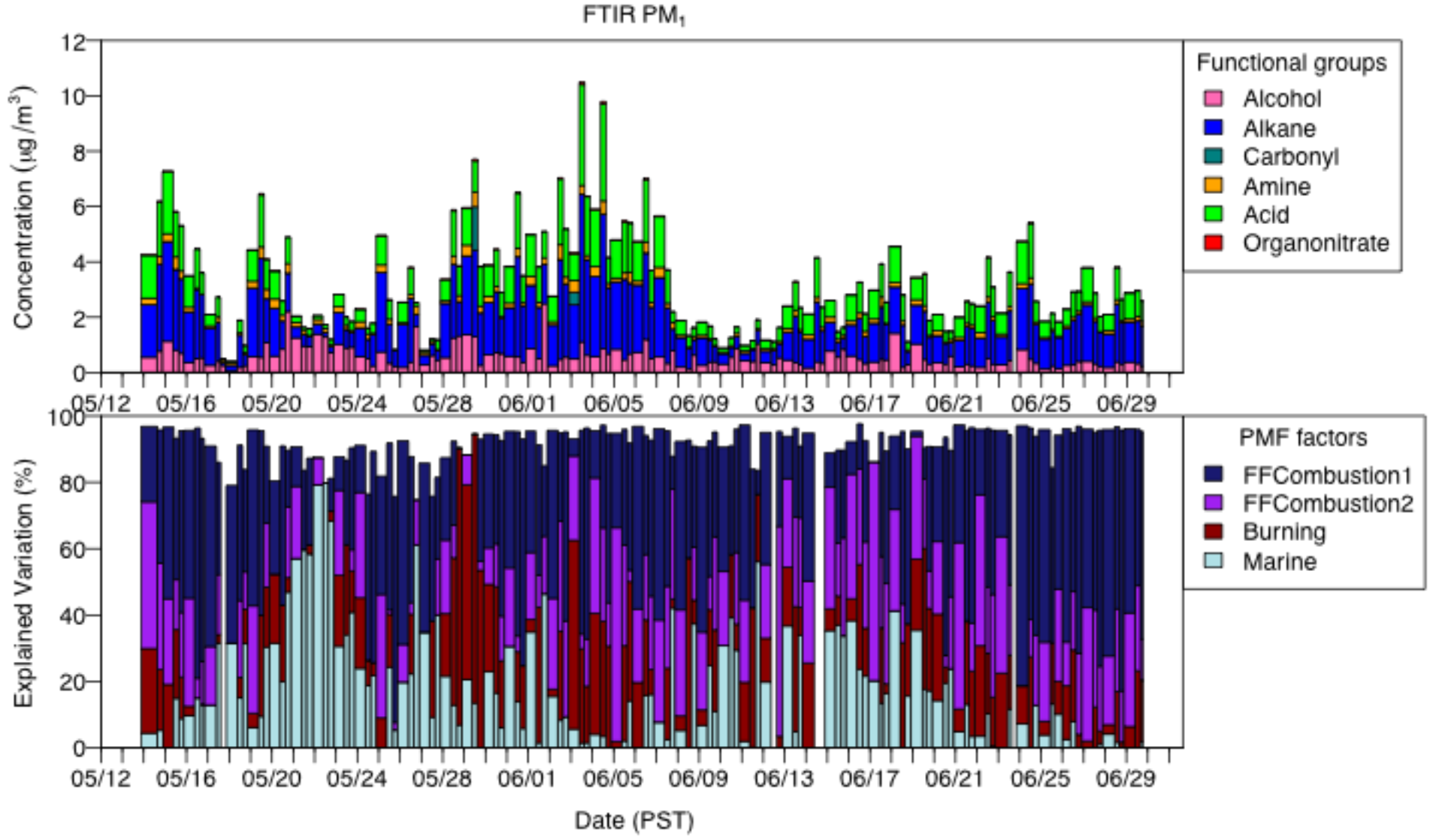
Adapted from S. Liu



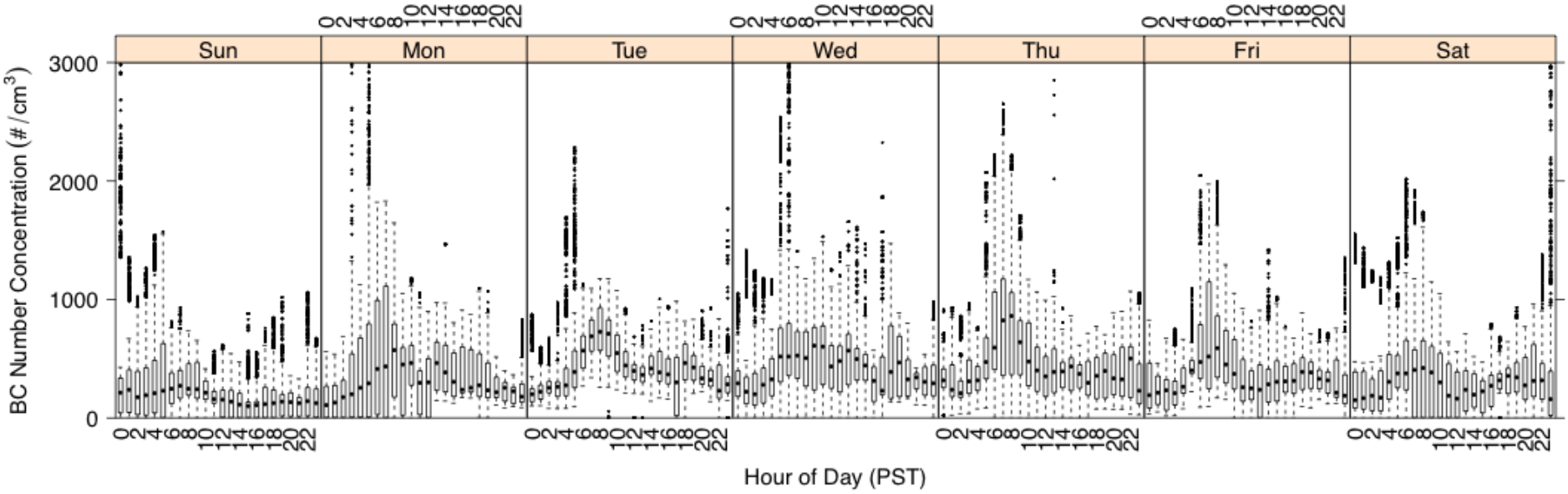
PMF factors

- Fossil-fuel combustion
  - 1 Less oxygenated (S, V)
  - 2 More oxygenated (S)
- Burning
  - Correlated with K
- Marine
  - Correlated with Na, Cl

Components from FTIR spectra decomposition

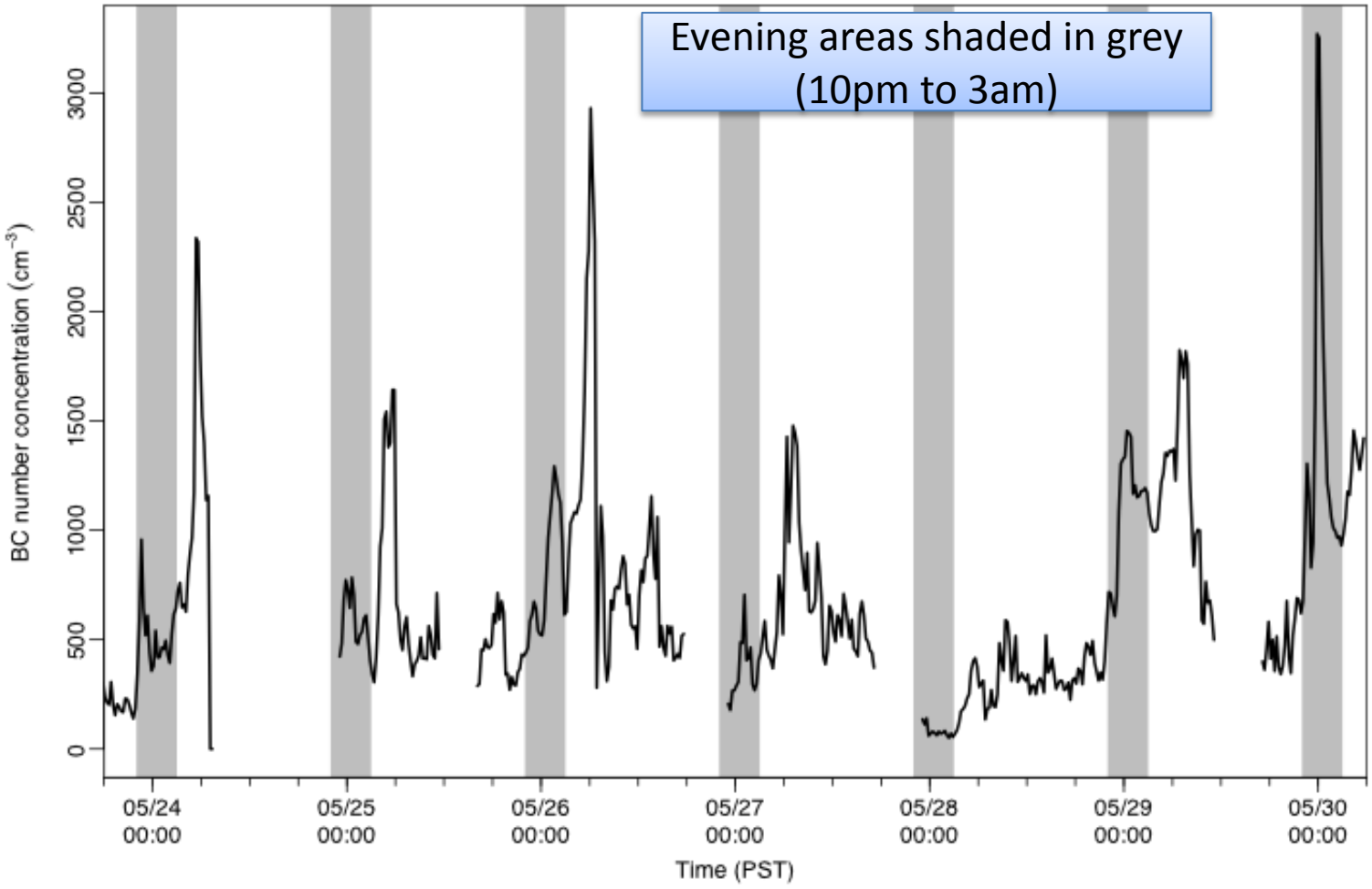


Temporal variations in BC number concentrations

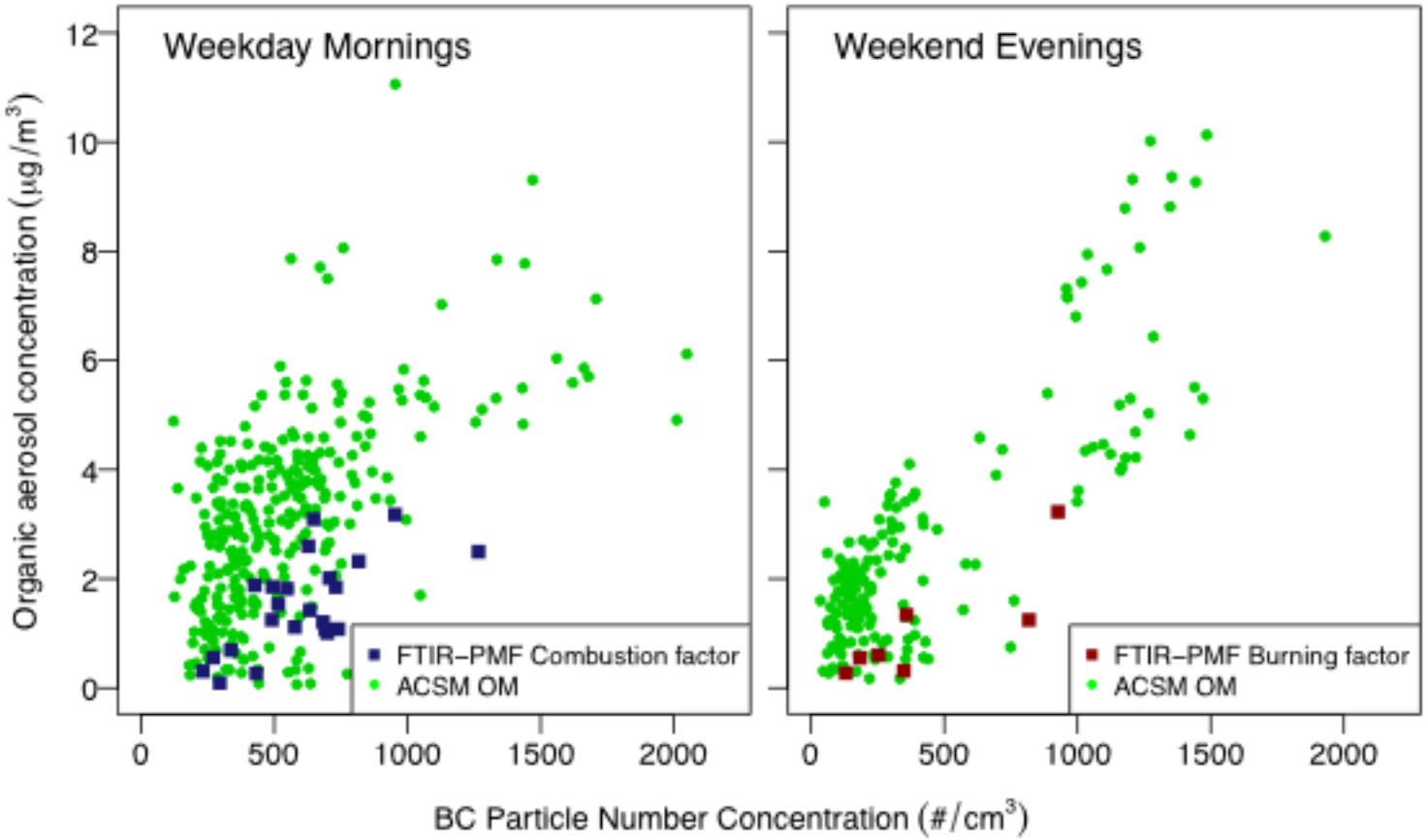


- Peak during morning hours daily
- Extreme values during weekend evenings

BC emission events during evening hours

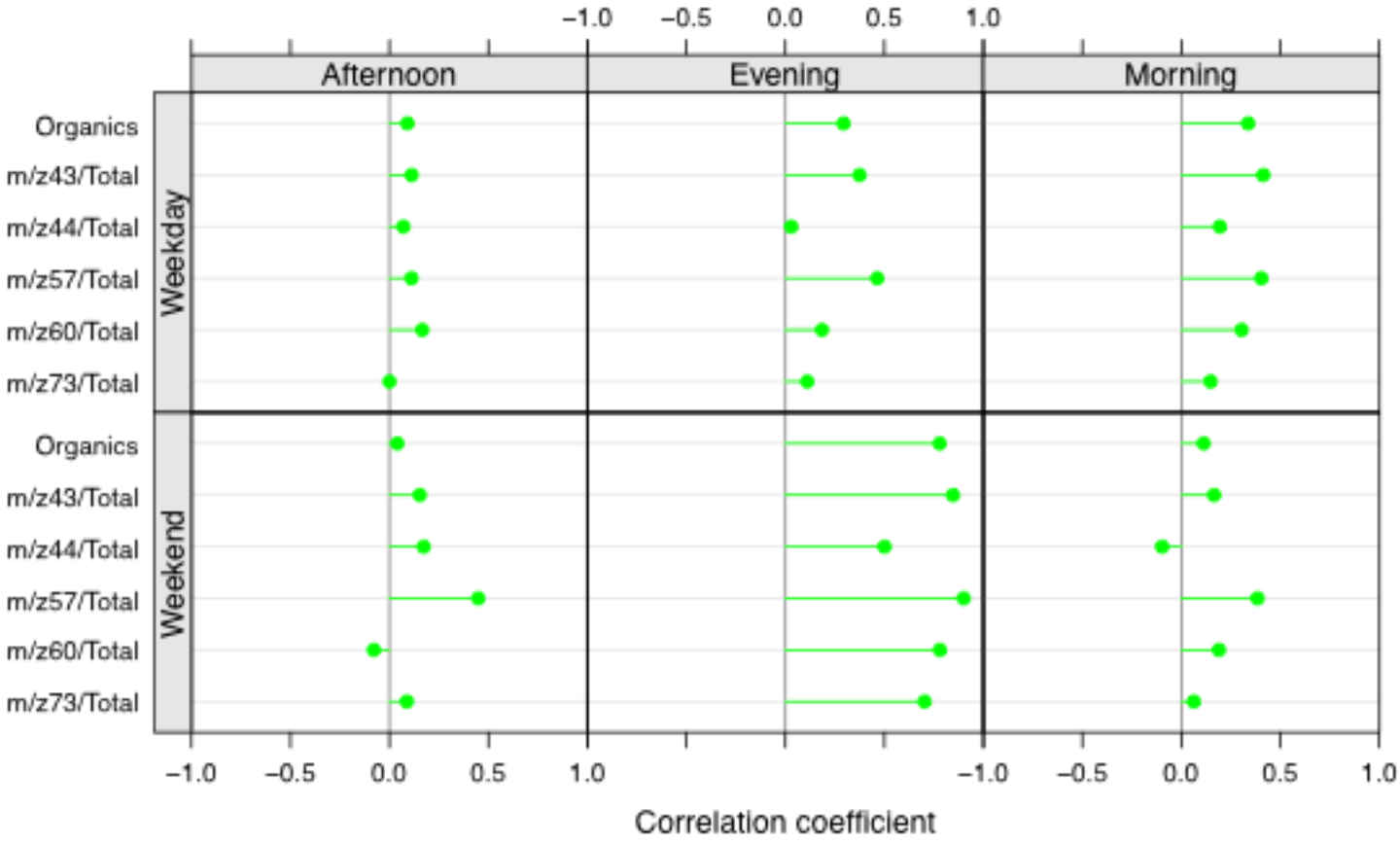


Association of black carbon with sources of organic PM



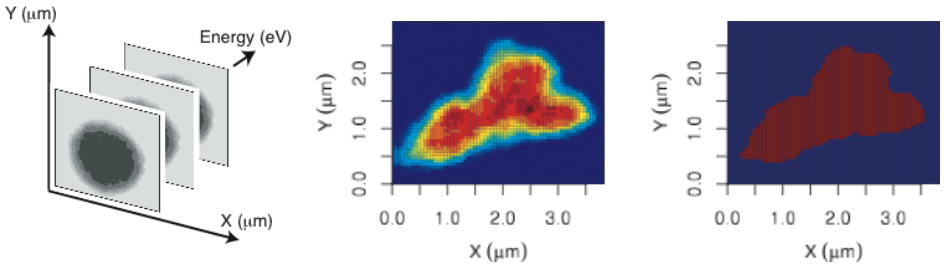
- Black carbon number concentrations correlate with organic aerosol measurements from ACSM on weekday mornings and weekend evenings.
- BC number concentrations also correlate with FTIR-PMF (Positive Matrix Factorization on FTIR spectra) combustion factor/component on on weekday mornings and FTIR-PMF Burning factor/component on weekend evenings.

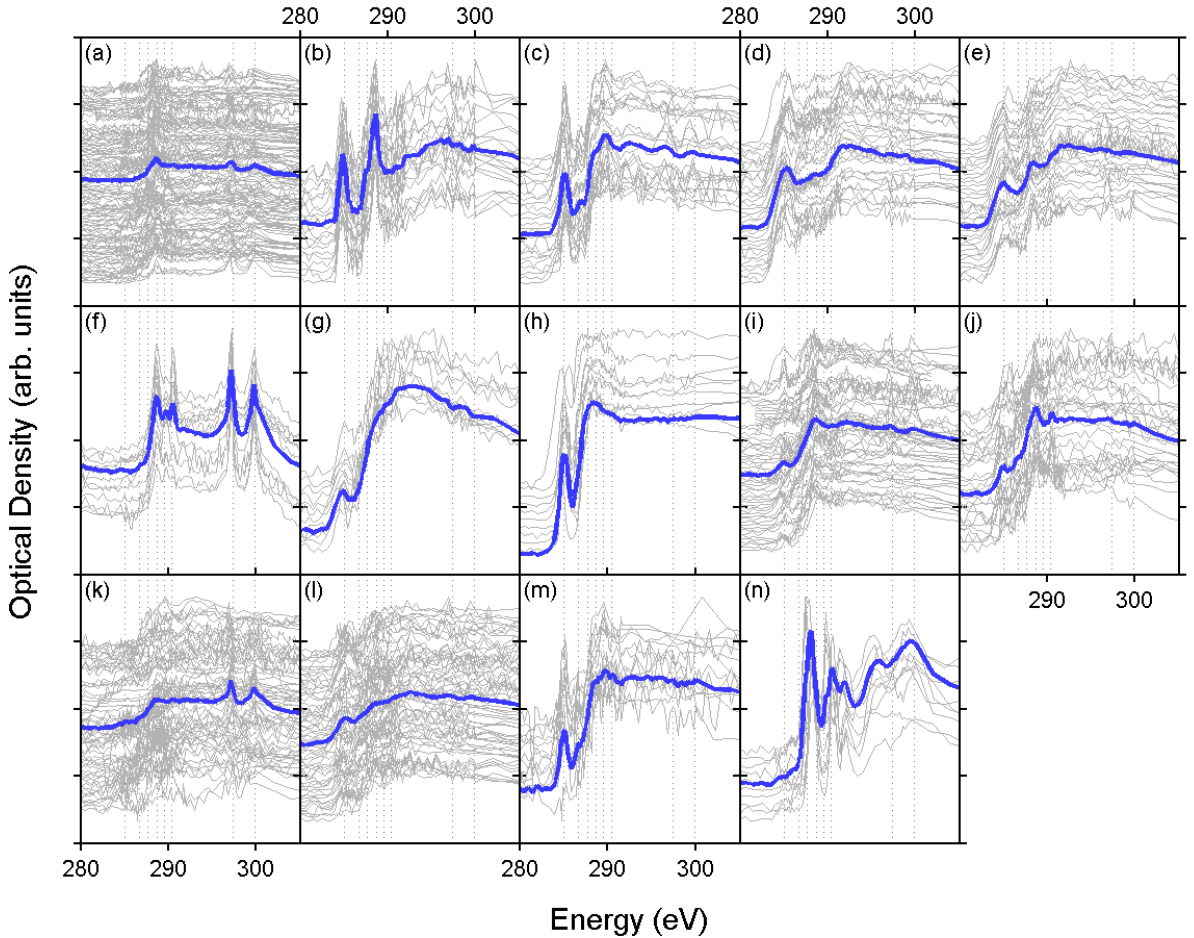
Correlation of BC number concentrations with ACSM mass fragments (markers)

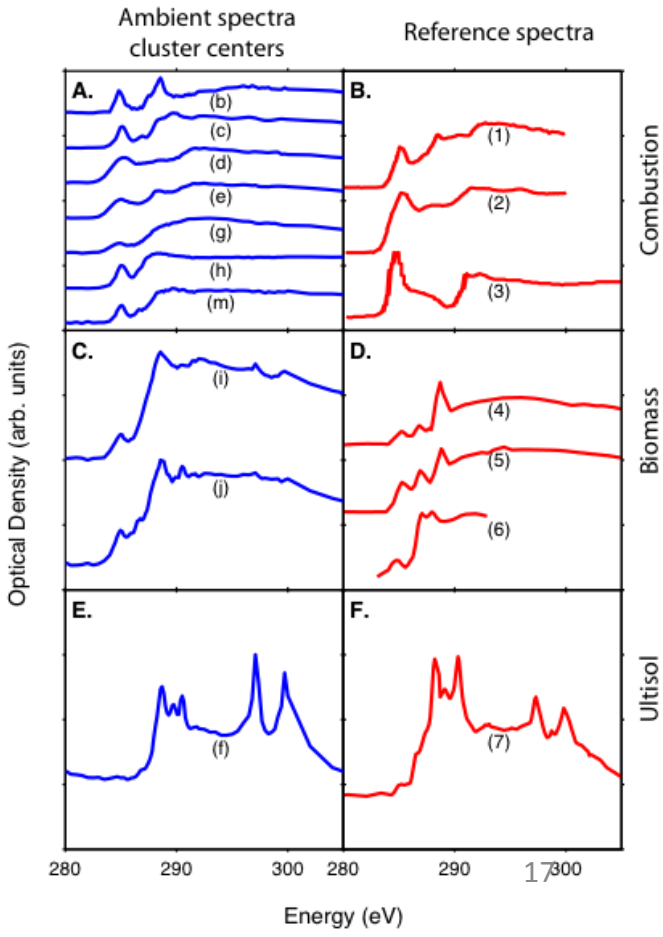


- Mass fragments: m/z 57, 60, 73 often associated with biomass burning.
- These mass fragments correlate strongest with BC number concentrations during weekend evenings.

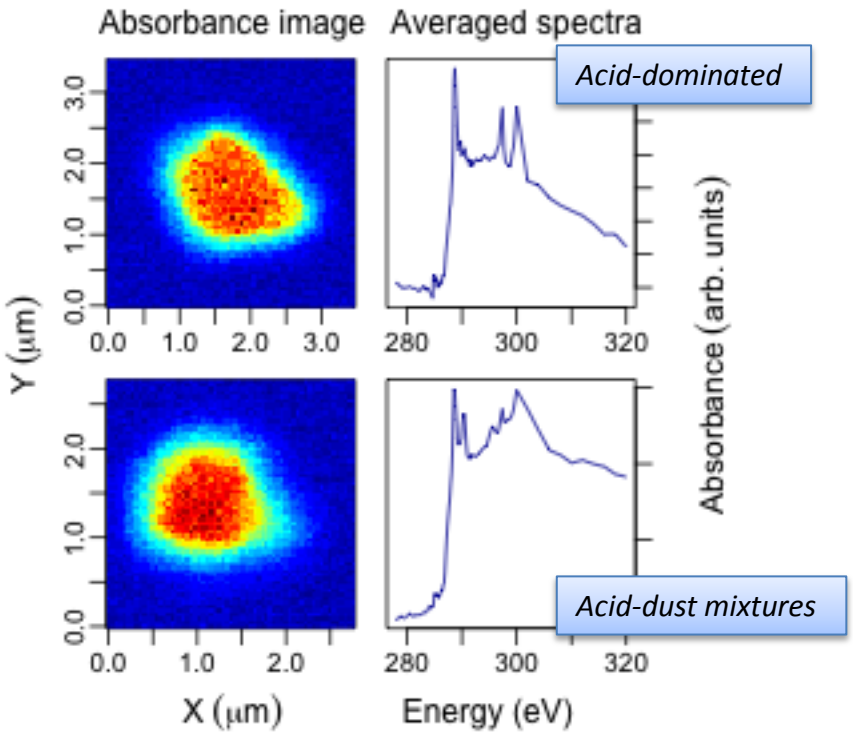
Shape and chemical distribution with X-ray microscopy





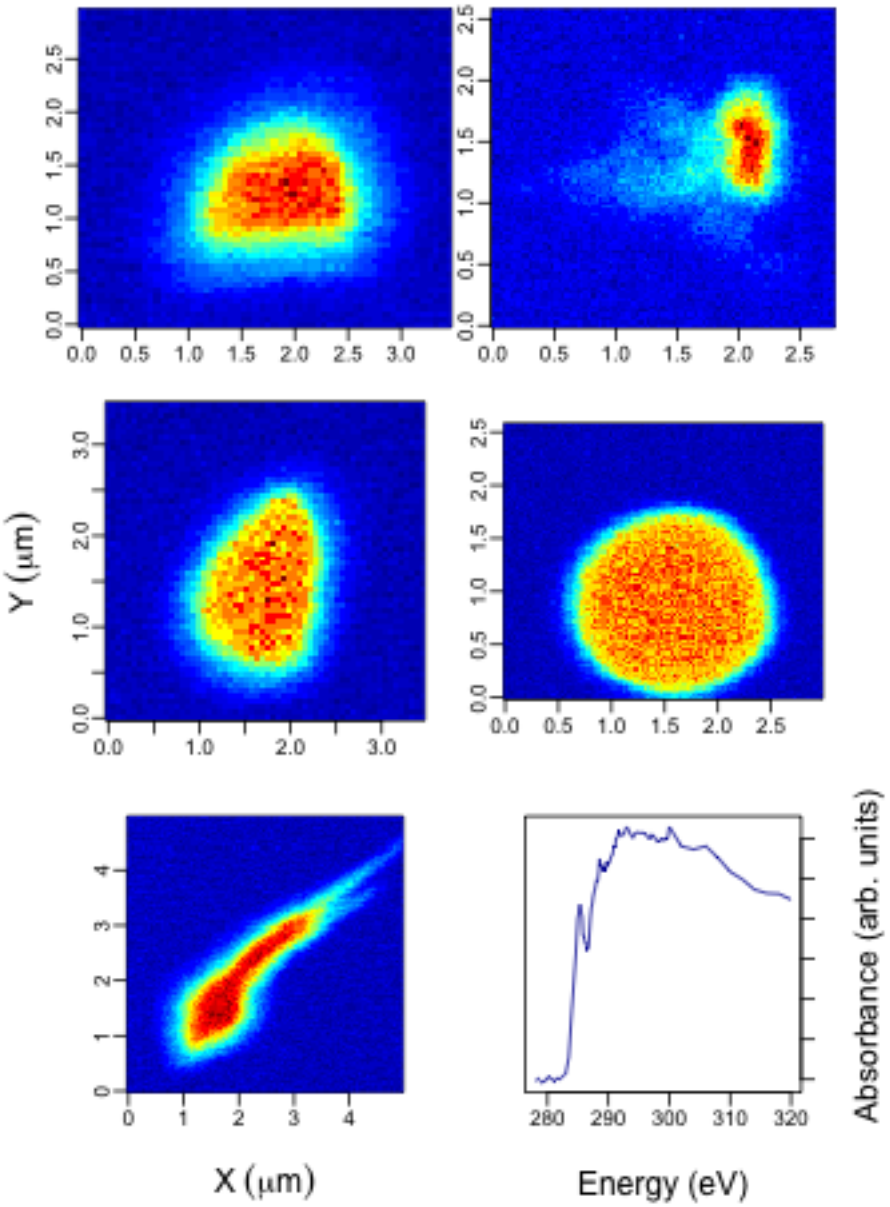


Particle types



Particle type	Number	Size range (mean) μm
Acid-dominated	6	1.4–4.6 (2.6)
Acid-dust mixtures	15	1–3.5 (2.1)
Black carbon	18	0.2–3.1 (1.5)

Black carbon particles



Conclusions

- Overall NR-PM_1 composition resembles observations made in S. California.
- Overall functional group composition resembles observations in other urban areas (Mexico City, Houston).
- Diurnal variations between weekday and weekend periods did not vary significantly.
- NR-PM_1 (including organic, ammonium, and nitrate) concentrations peaked in the morning.
- BC number concentrations also peaked in the morning.
- BC sources were associated with traffic and biomass burning events.