Improving Emission Inventories Using Direct Flux Measurements and Modeling

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Acknowledgements

Houston Yellow Cab

TARC (establishing the site, VOCs)

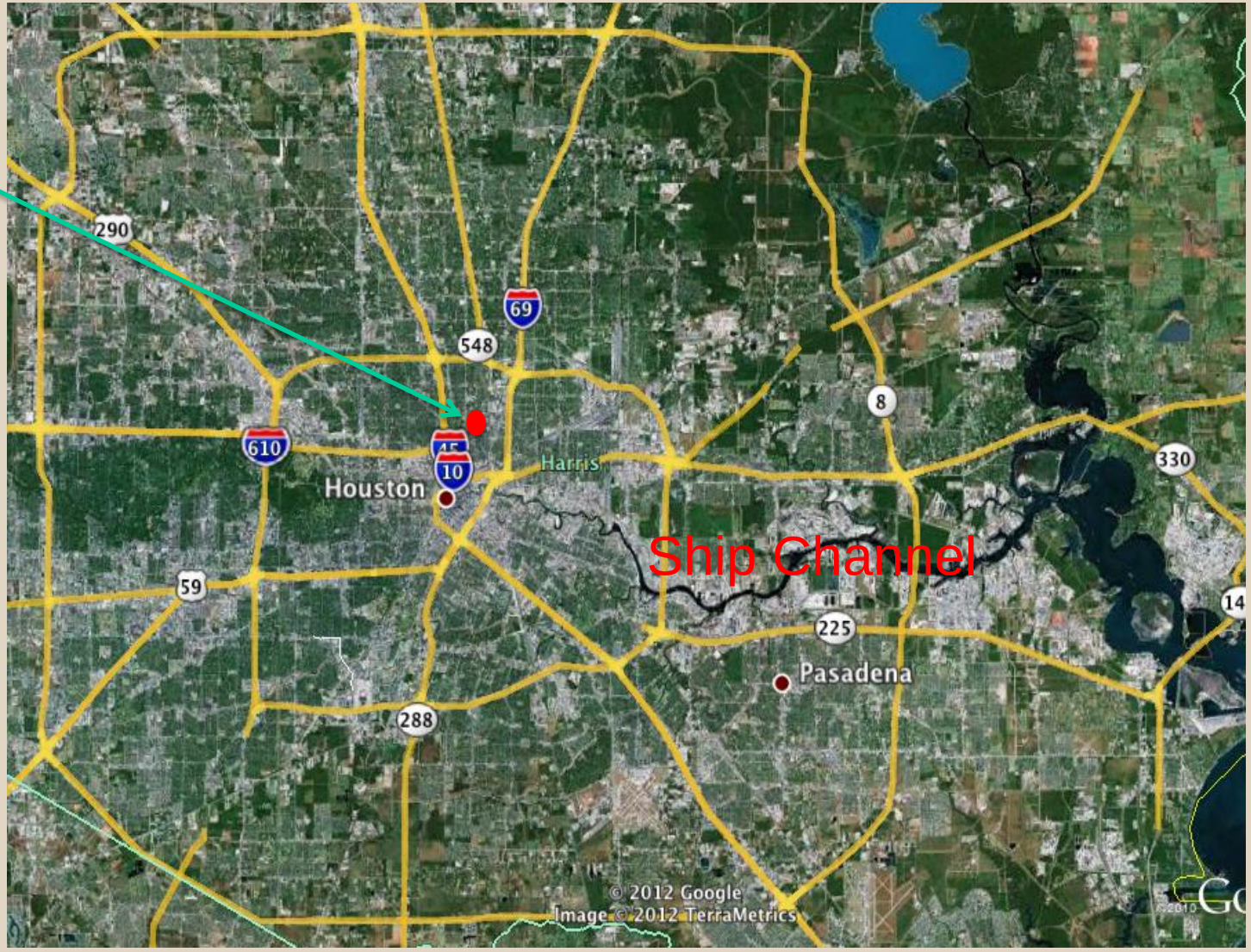
EPA-STAR (criteria pollutants & VOCs)

NOAA-GCC (carbon fluxes)

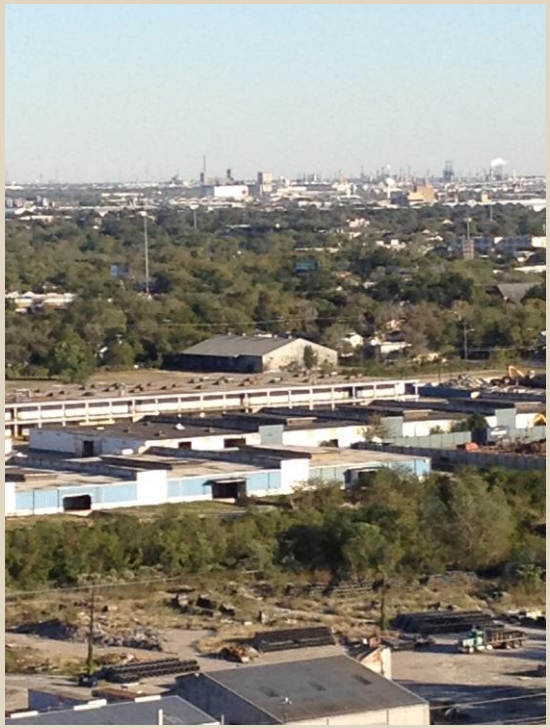
Outline

- Location and measurements
- Site Description
- CO_2 fluxes
  - Traffic Counts
- CO & NO_x fluxes
- VOC fluxes
- Tracer release and testing of footprint model
- Conclusions

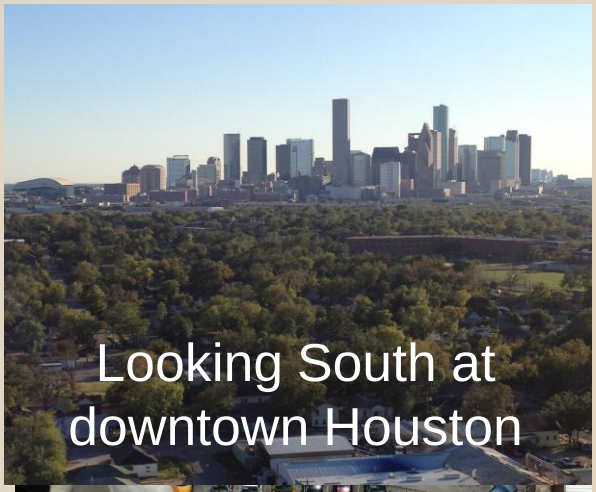
Site Description, I



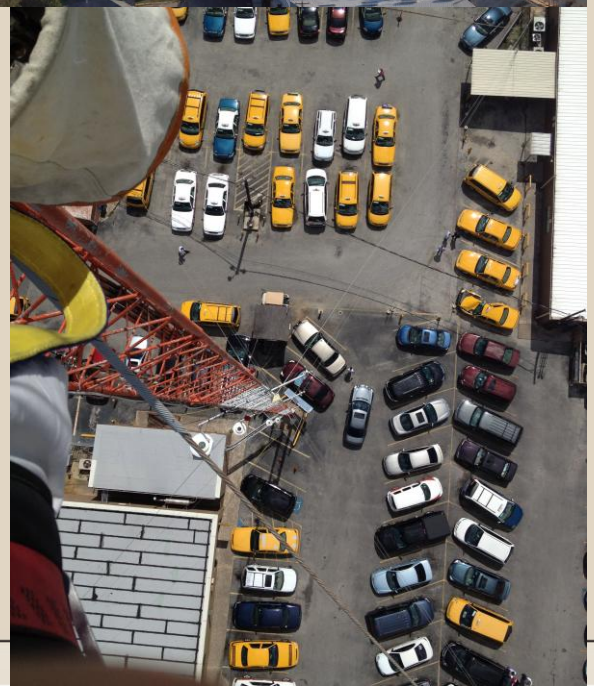
Views From the Sampling Point on the Tower

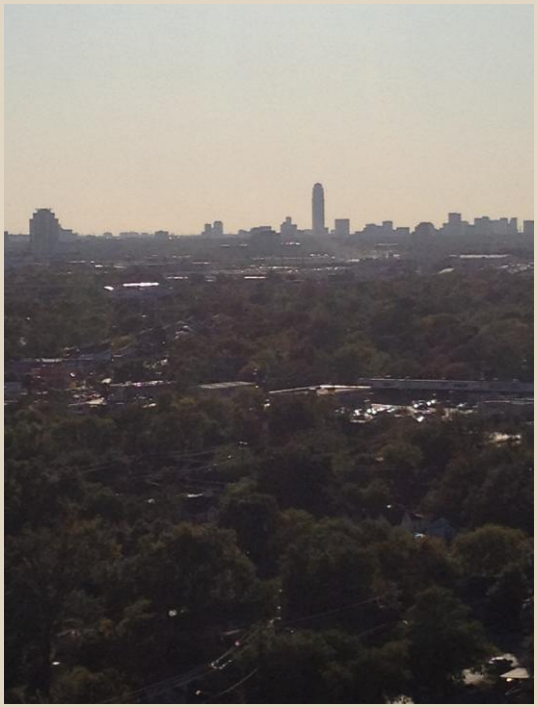


Looking ESE at the ship channel refineries



Looking South at downtown Houston





Looking WSW at the Galleria area

Site Description, II

land use

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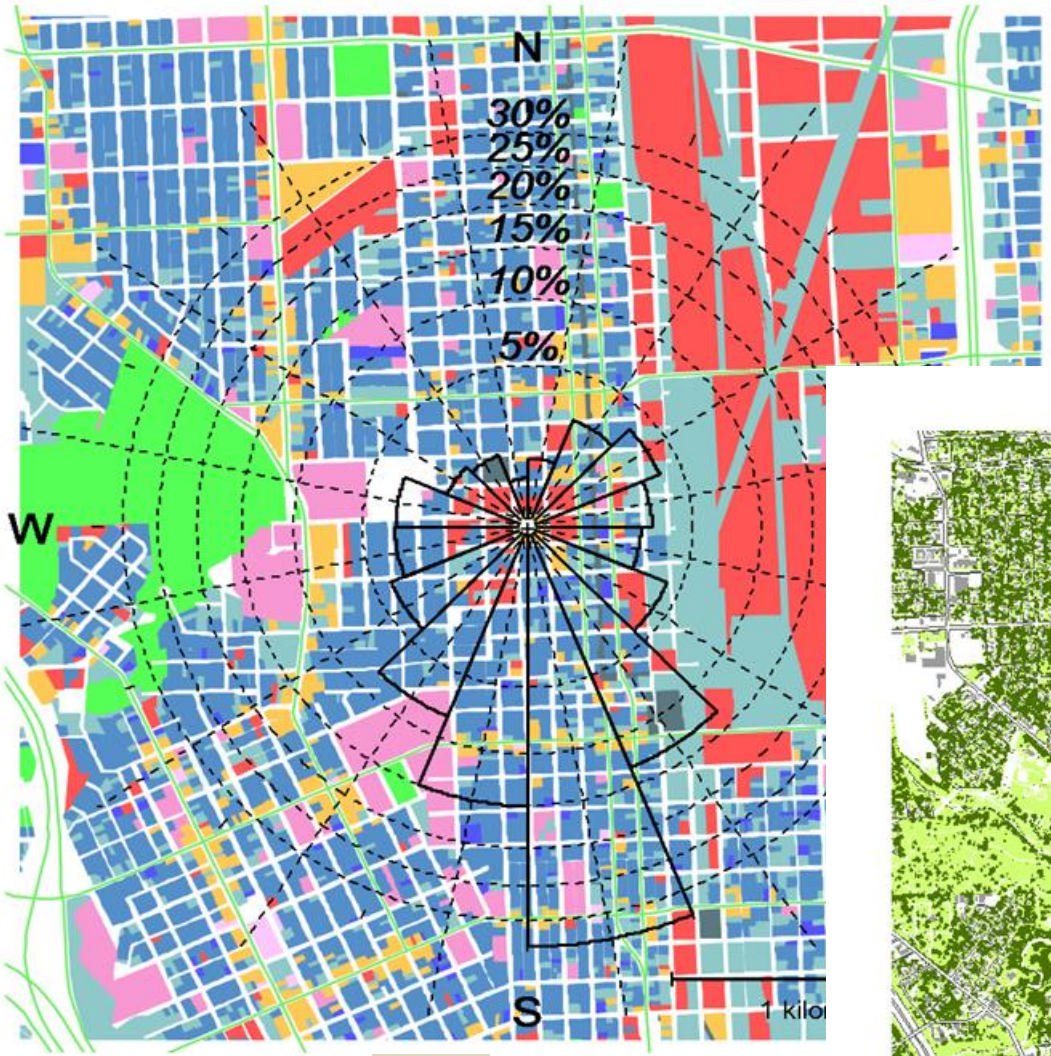
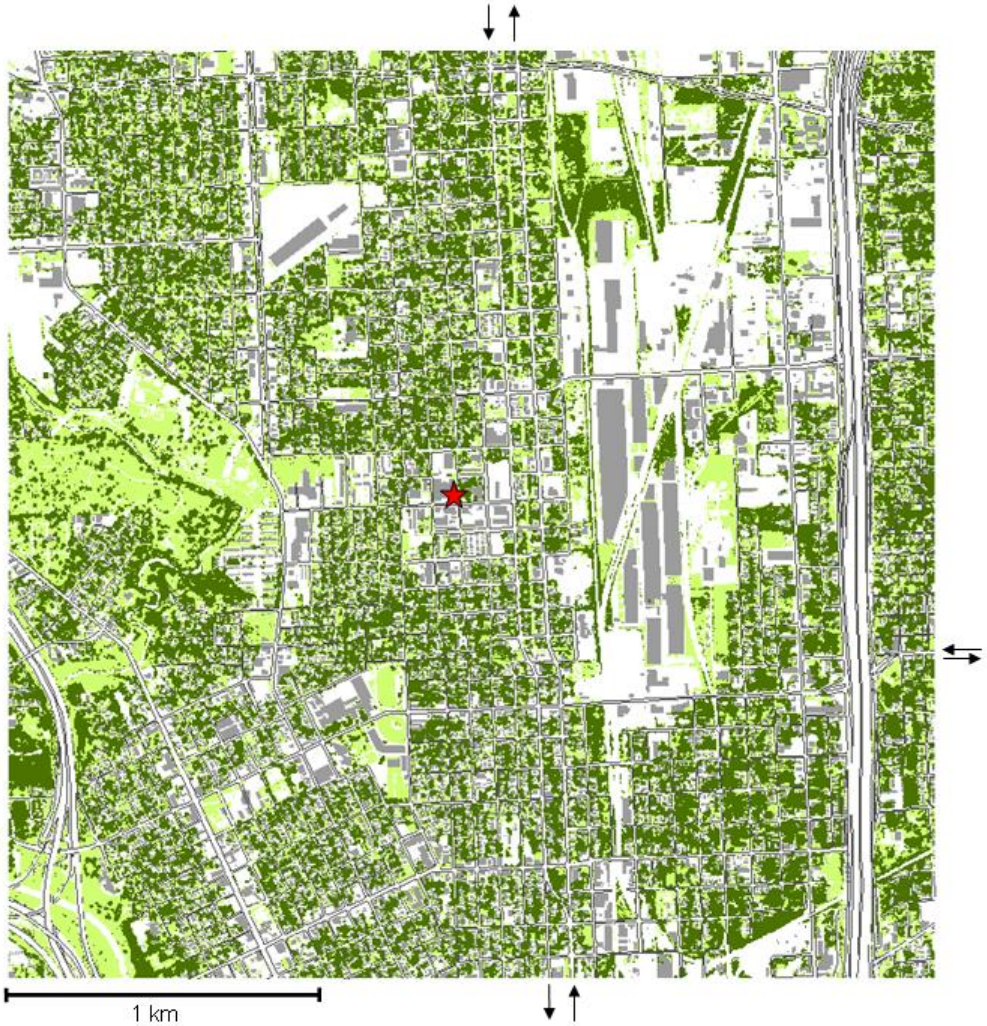
land cover

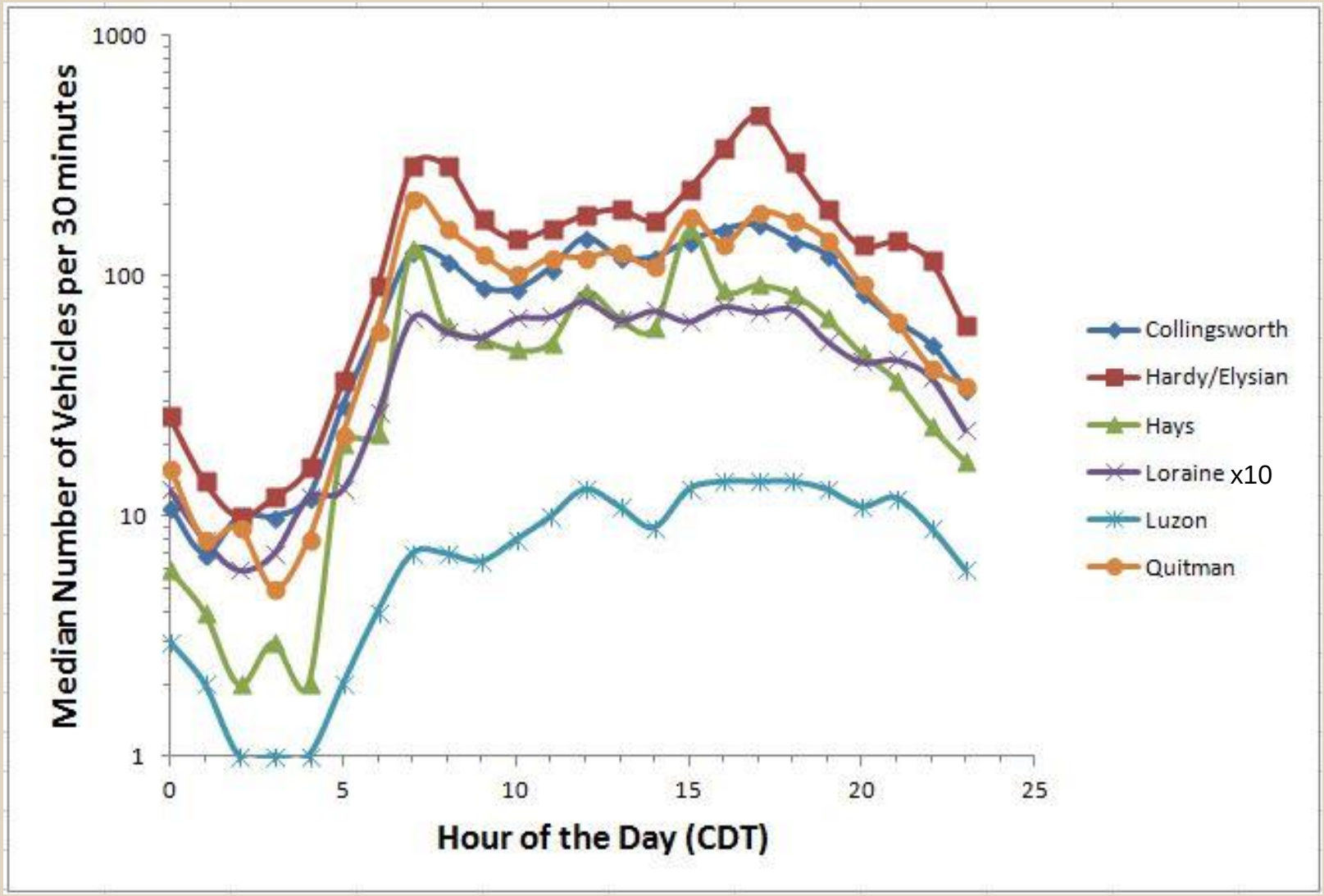


- Residential area
- Industrial area
- Commercial area
- Public/institutional area
- Park and open space
- Undeveloped land
- Roads

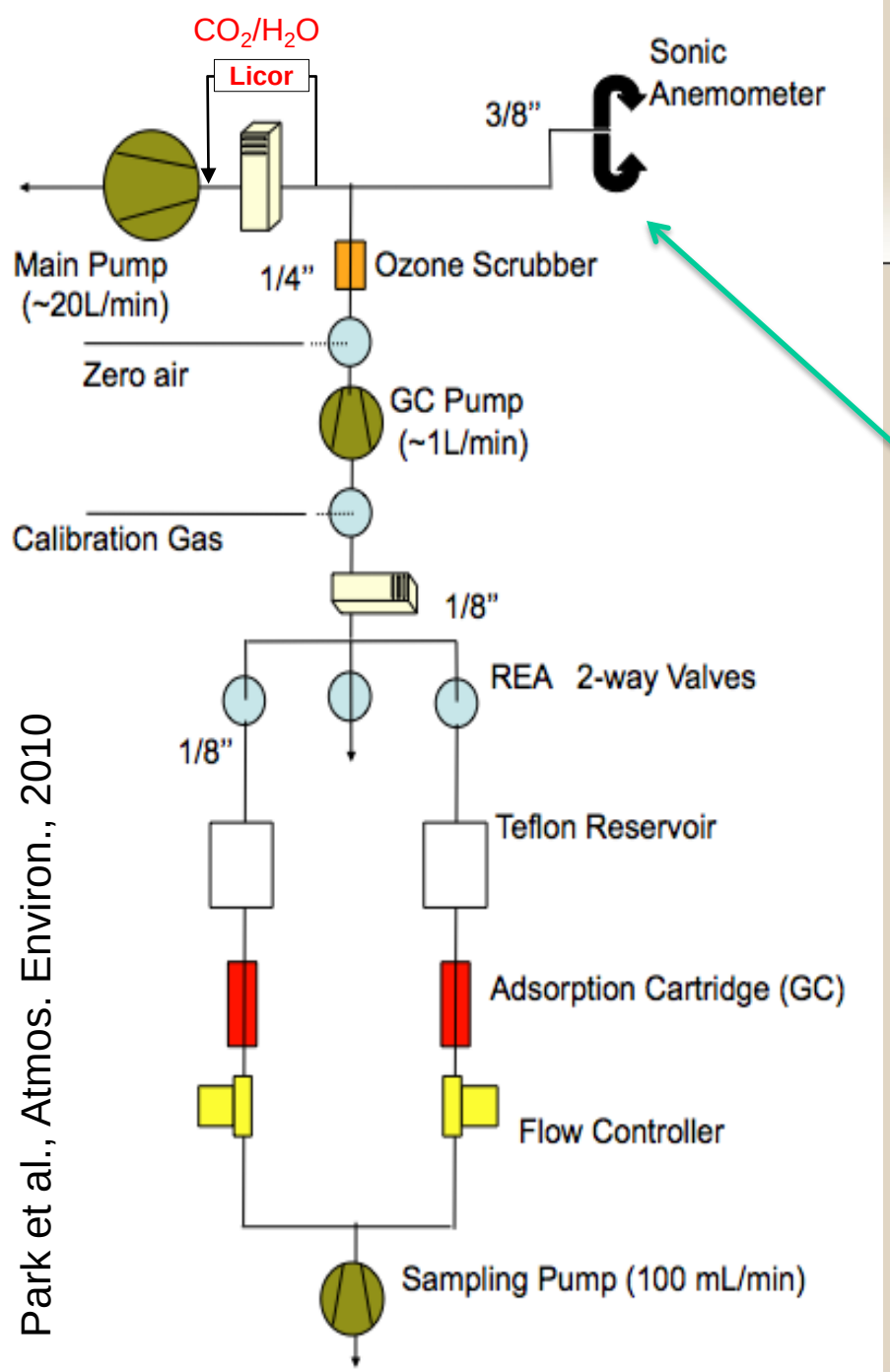
- Tree Crown
- Grass
- Building
- Edge of Pavement
- Flux Tower
- Hardy St.
- Elysian St.



Traffic counts

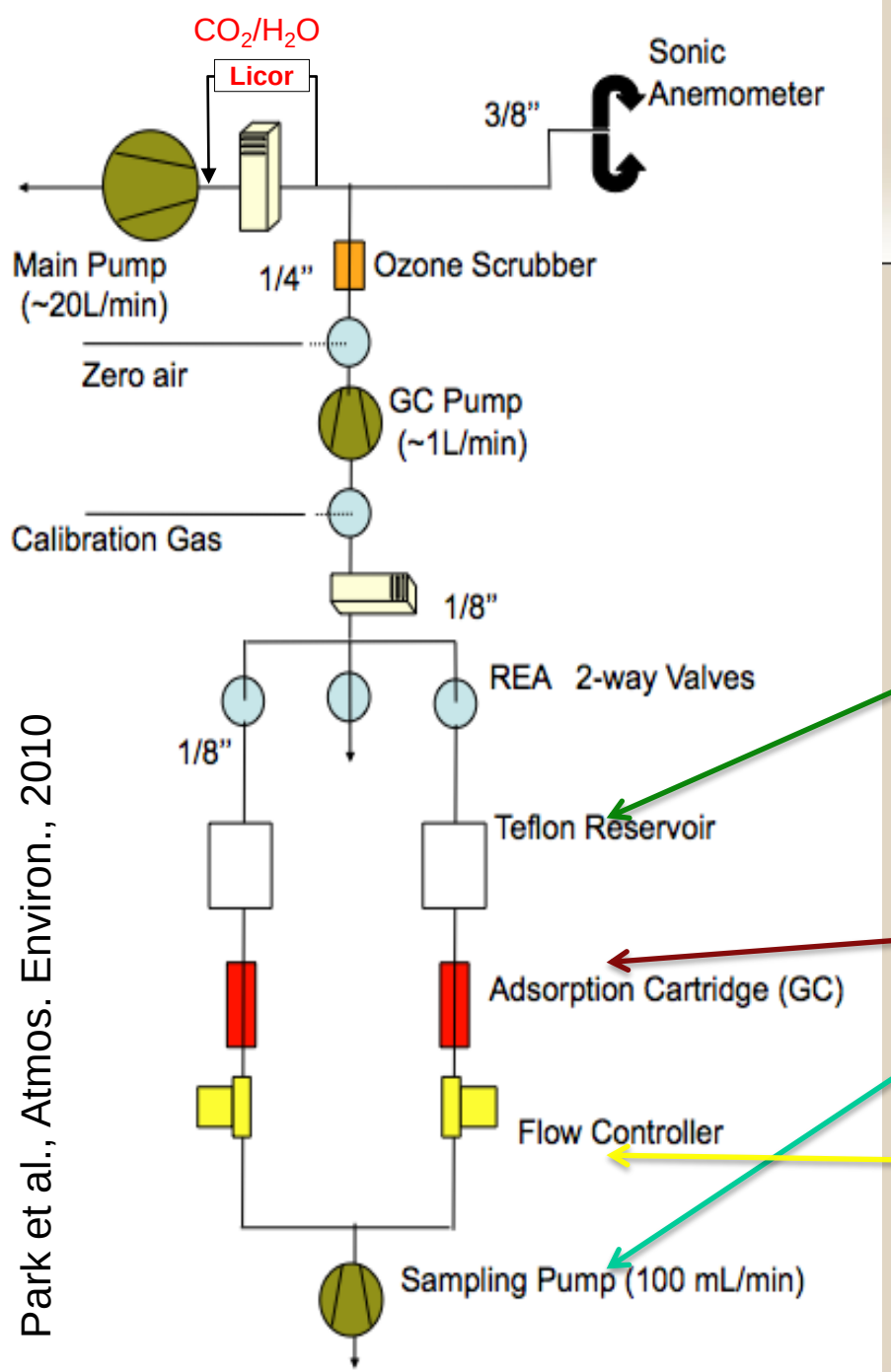


Setup

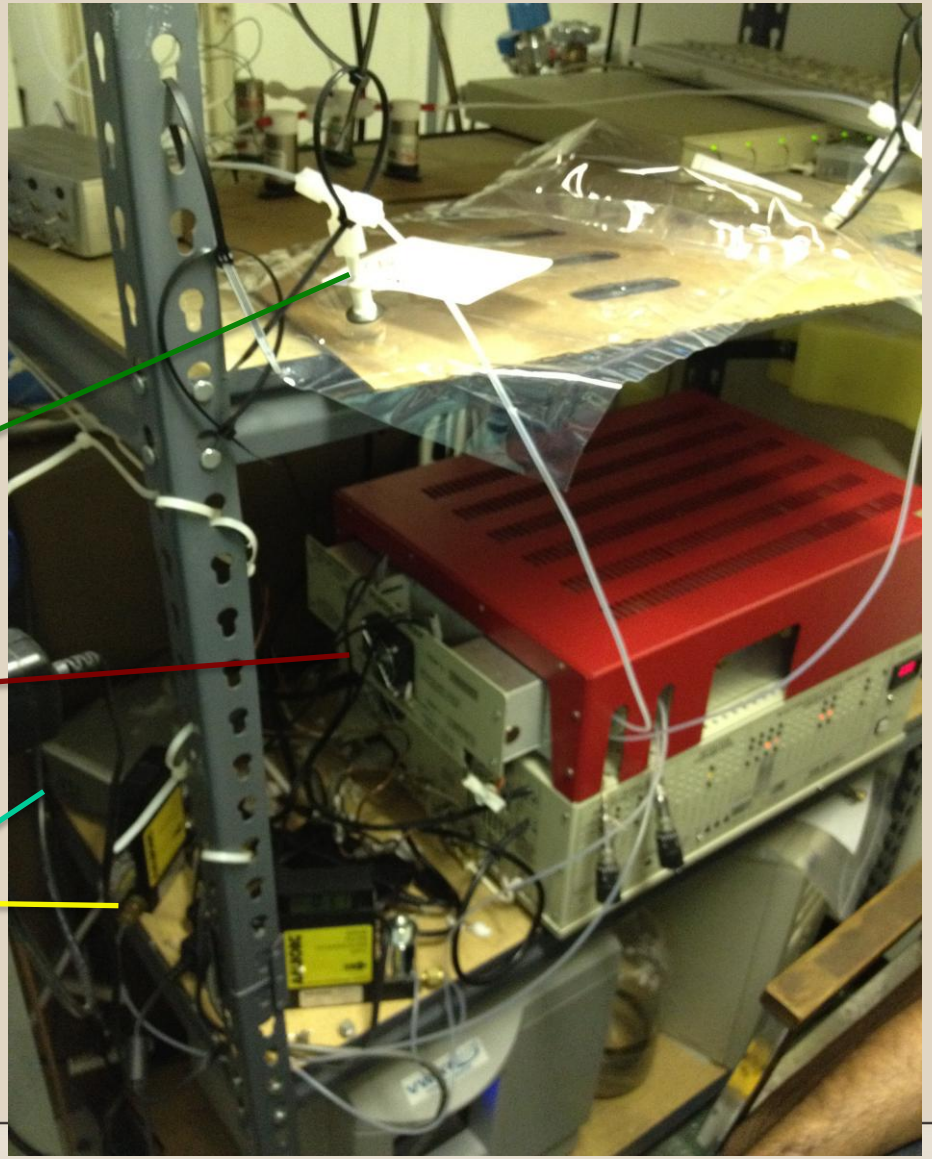


Park et al., Atmos. Environ., 2010

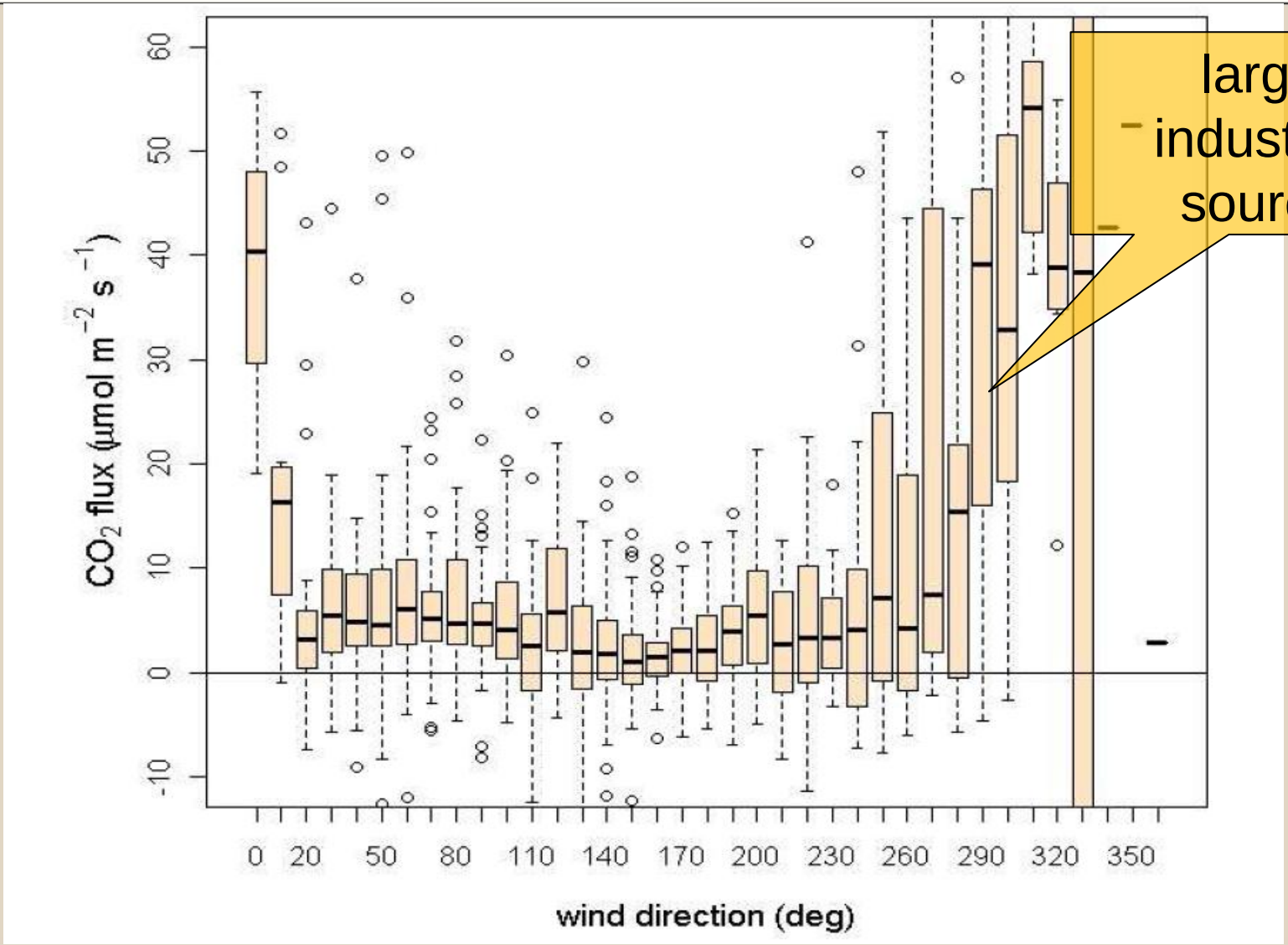
Setup



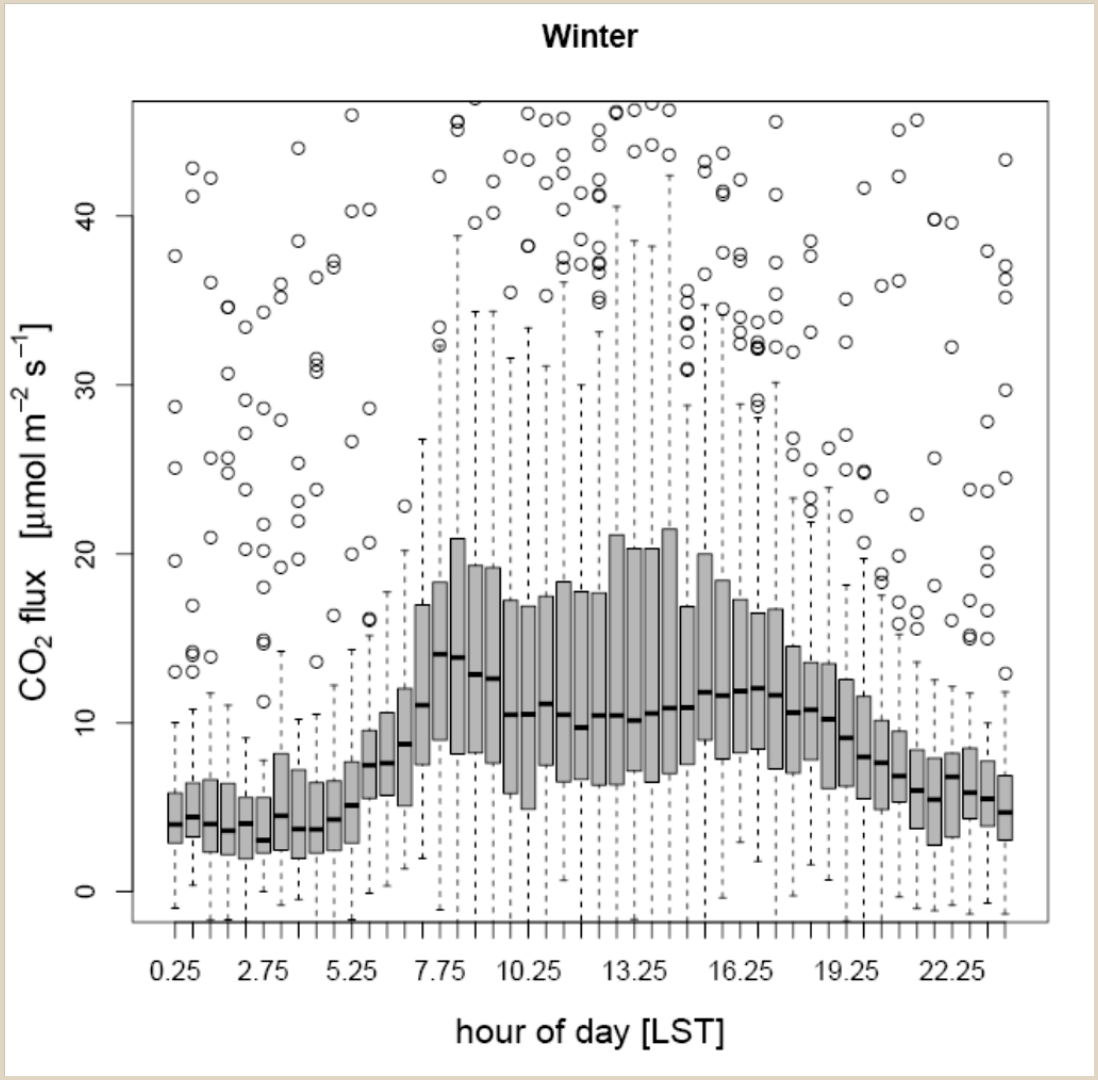
Park et al., Atmos. Environ., 2010



CO_2 fluxes, I

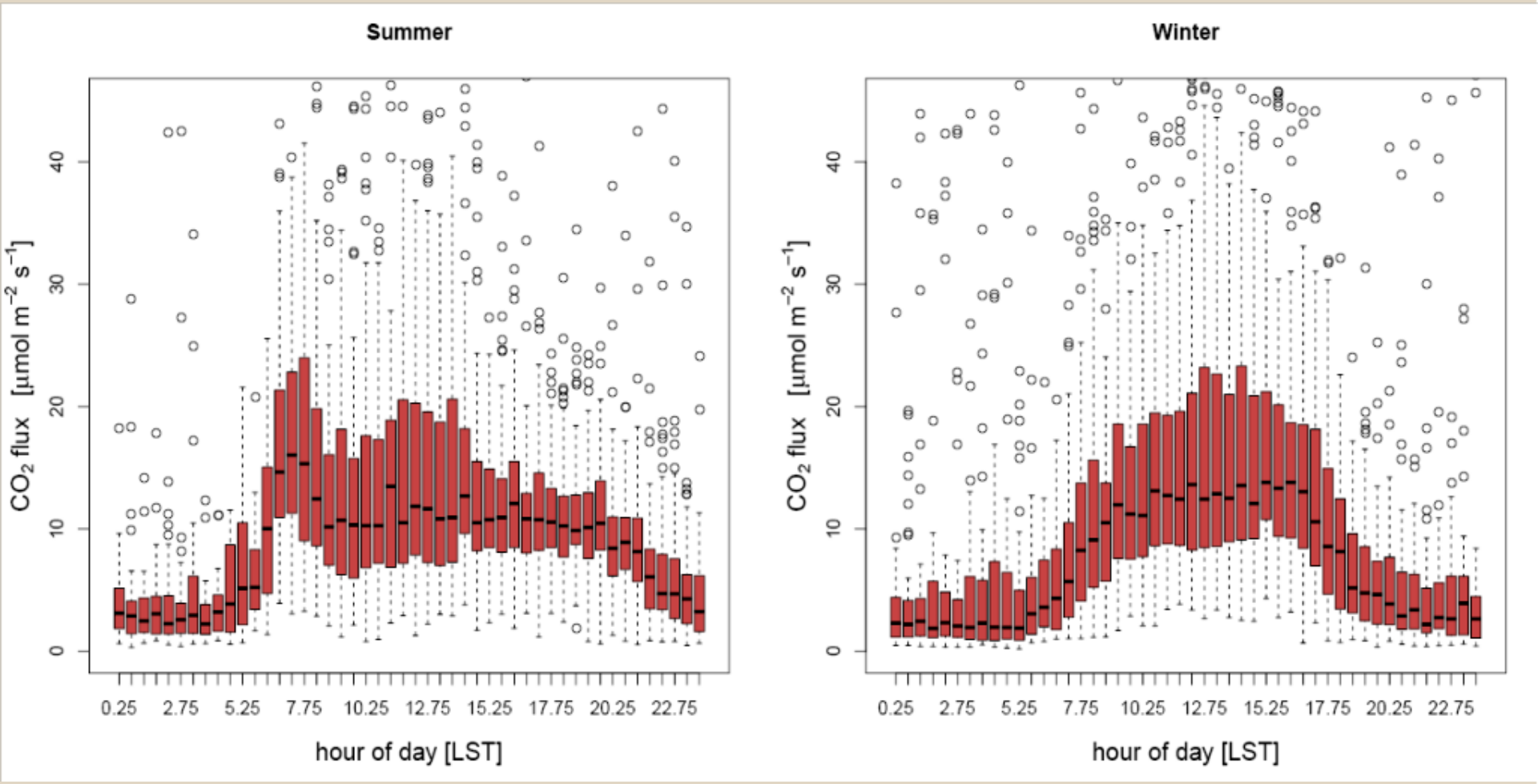

large
industrial
source
CO_2 flux (μmol m^{-2} s^{-1})
-10
0
10
20
30
40
50
60
0
20
50
80
110
140
170
200
230
260
290
320
350
wind direction (deg)

CO_2 fluxes, II



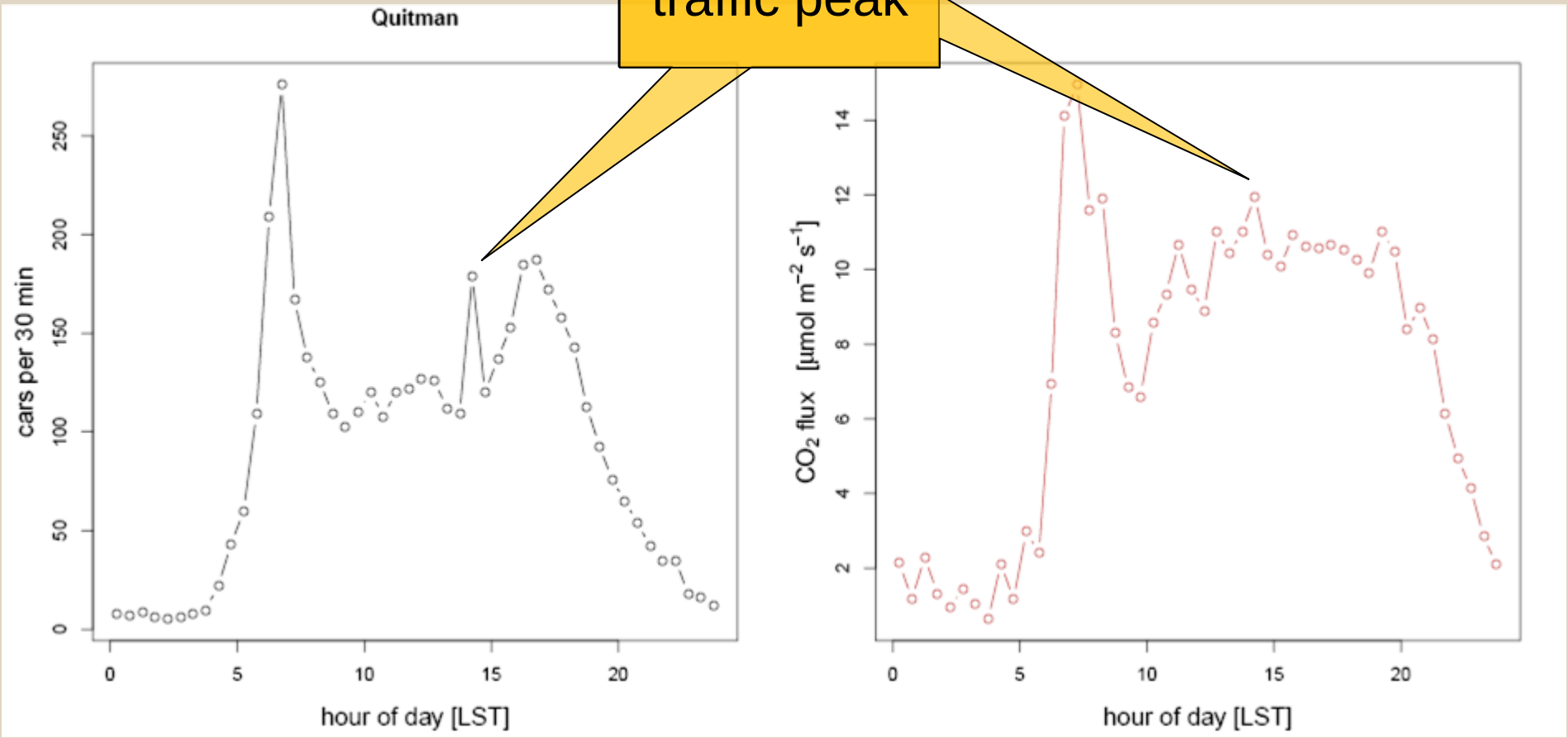
- not as strongly driven by traffic as expected
- net fluxes affected by biogenic uptake

CO_2 fluxes, III



CO_2 fluxes, IV

School traffic peak

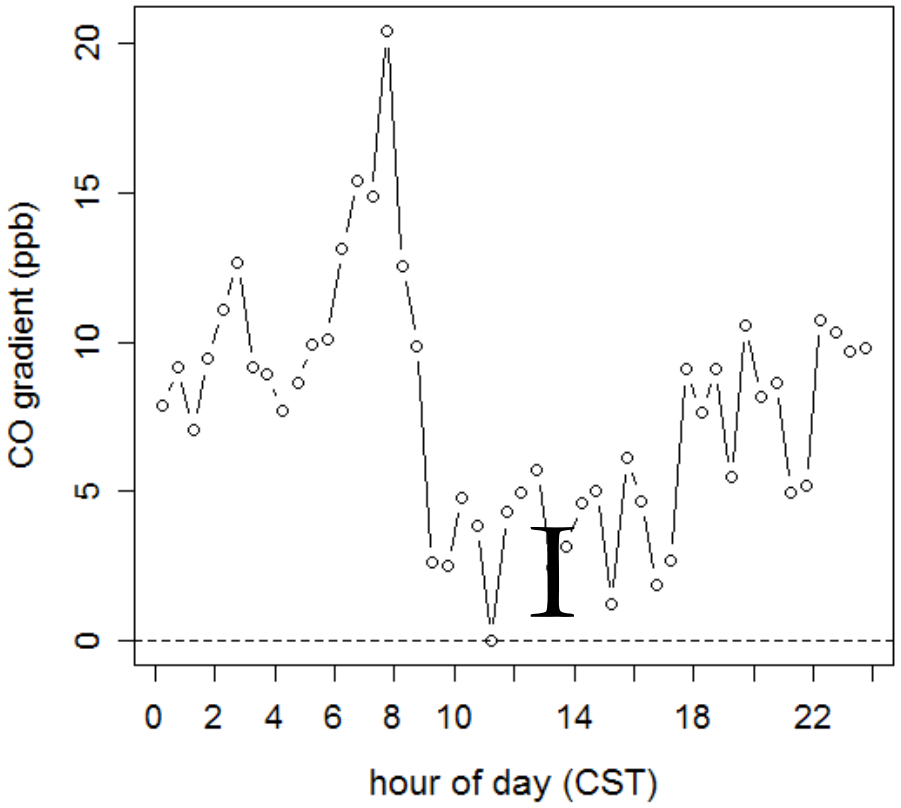


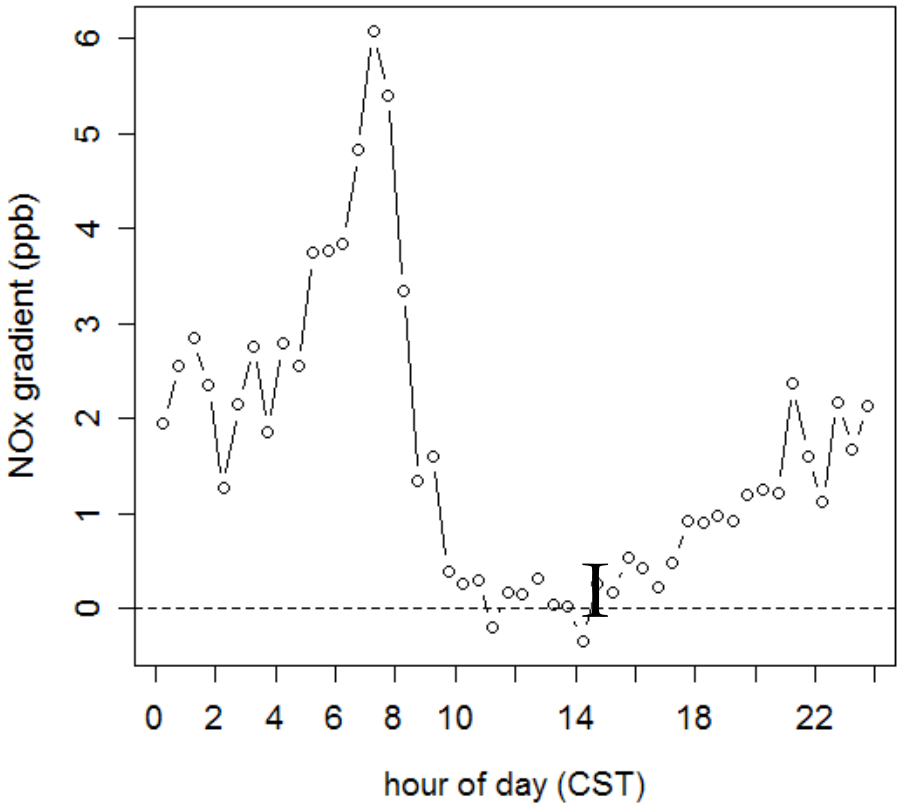
Anthropogenic CO_2-flux = 10 µmol m^{-2} s^{-1}

60% car traffic (from CO flux data), 20-30% human respiration (residual),

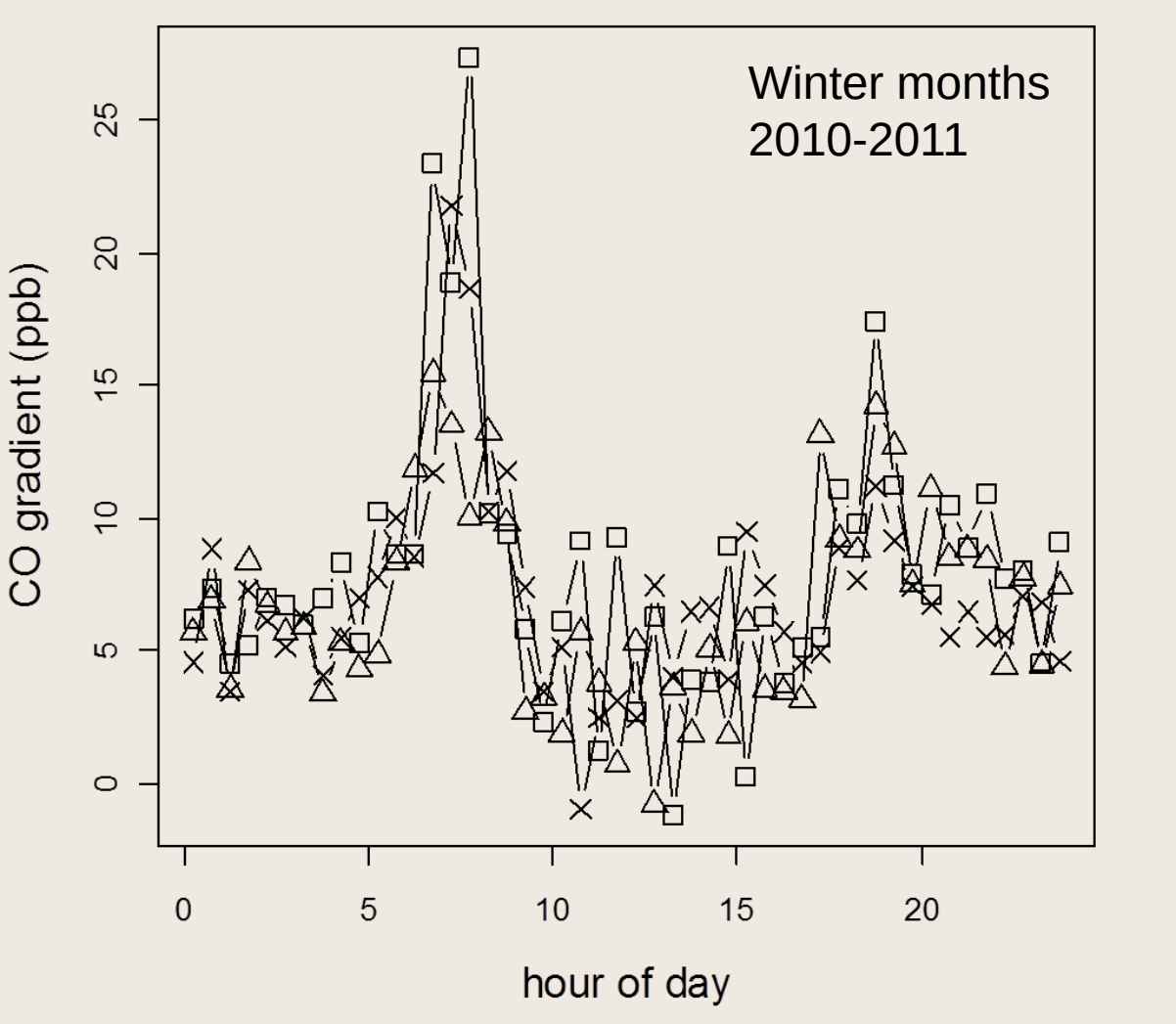
20-10% soil respiration (uncertain), <10% natural gas use (local data)

Criteria Pollutant Fluxes, I

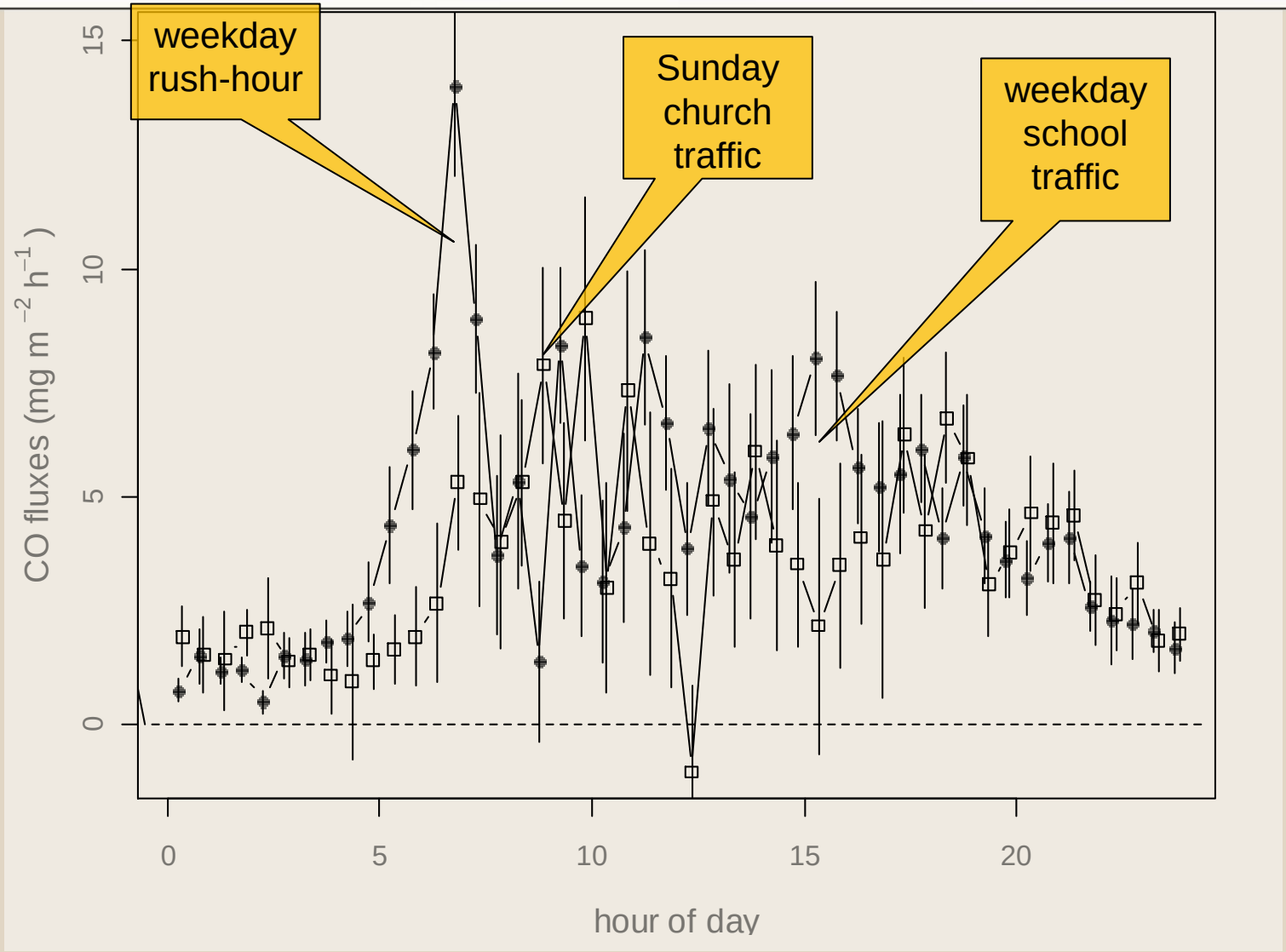




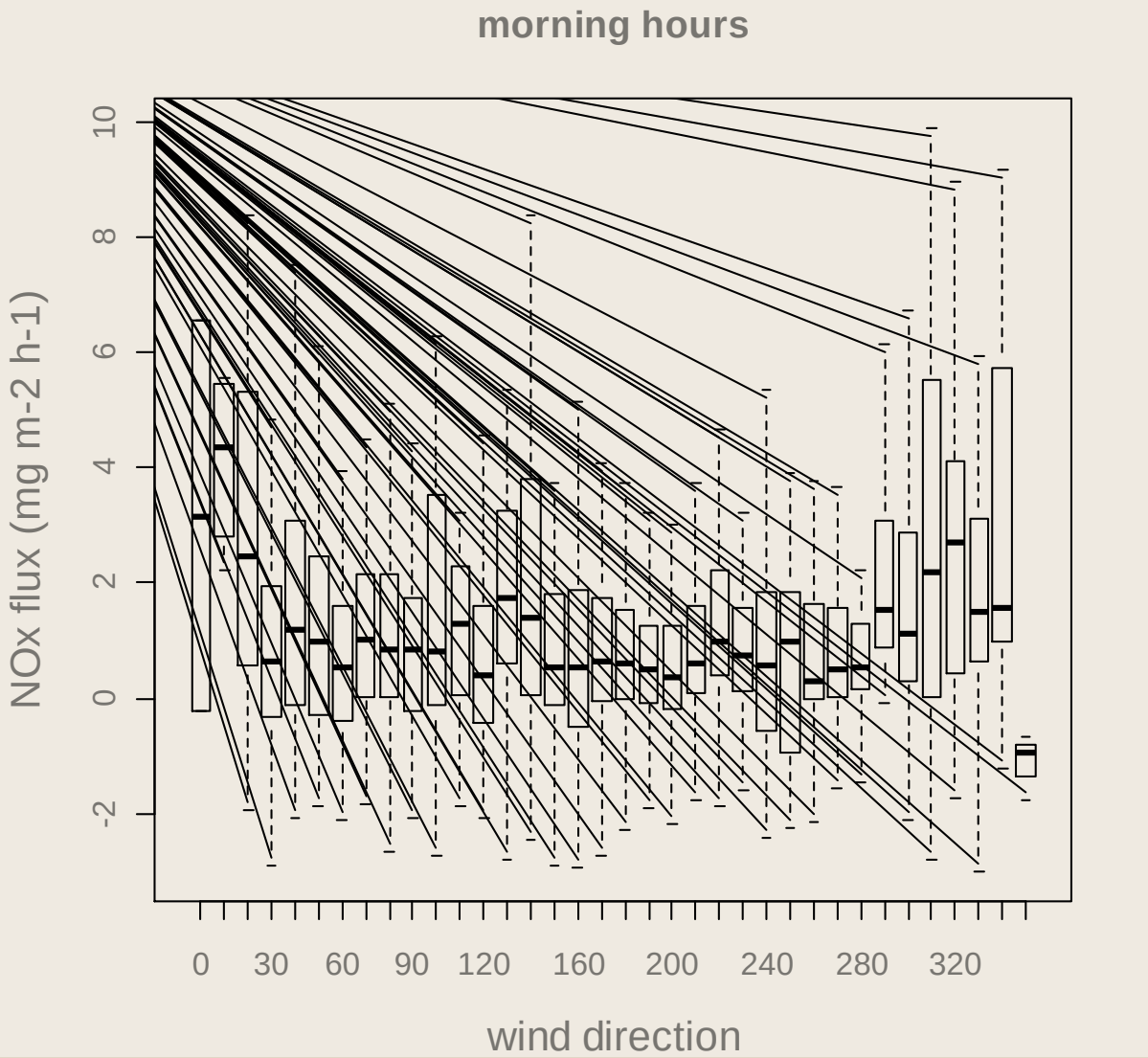
Criteria Pollutant Fluxes, II



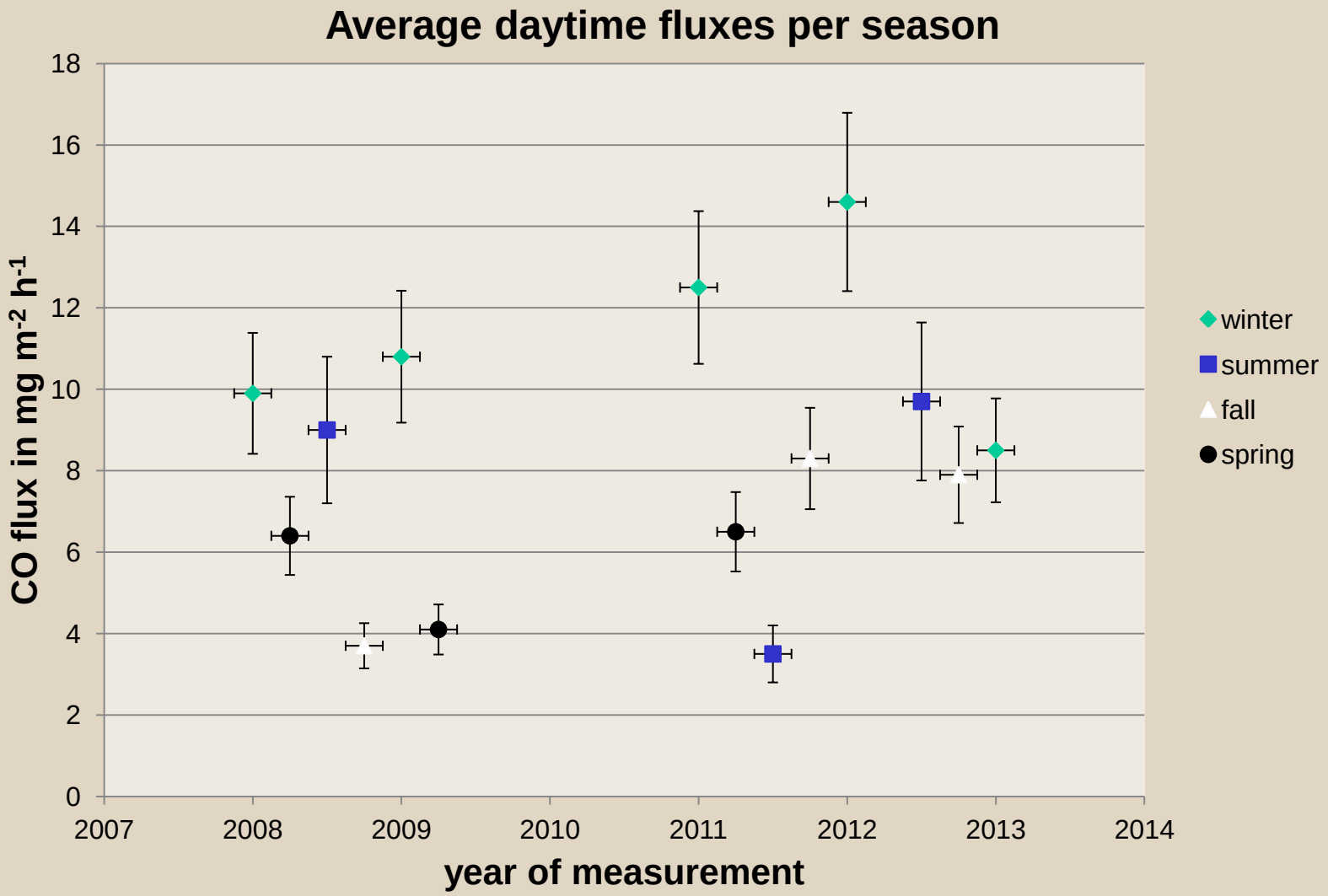
Criteria Pollutant Fluxes, III



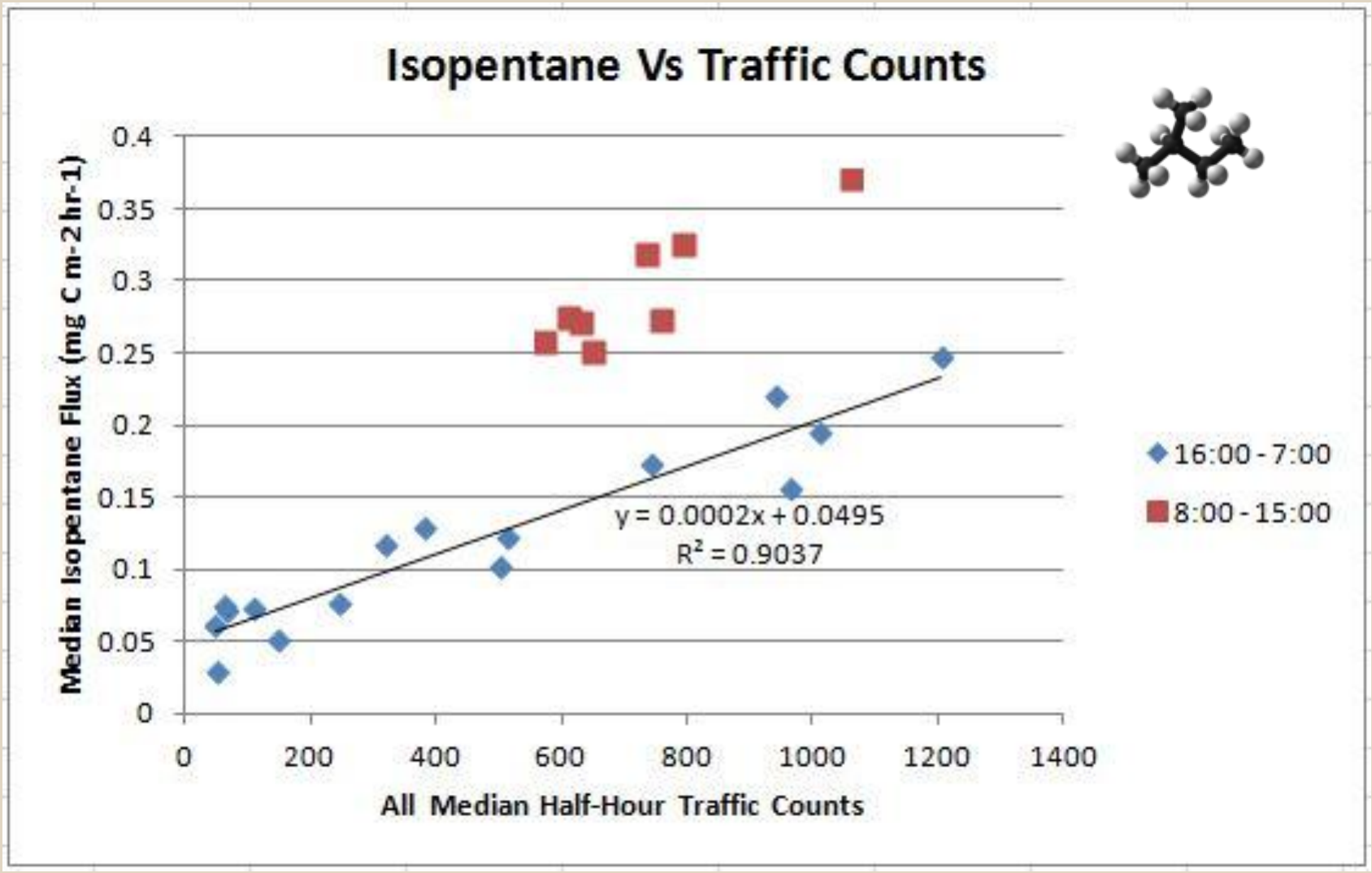
Criteria Pollutant Fluxes, IV



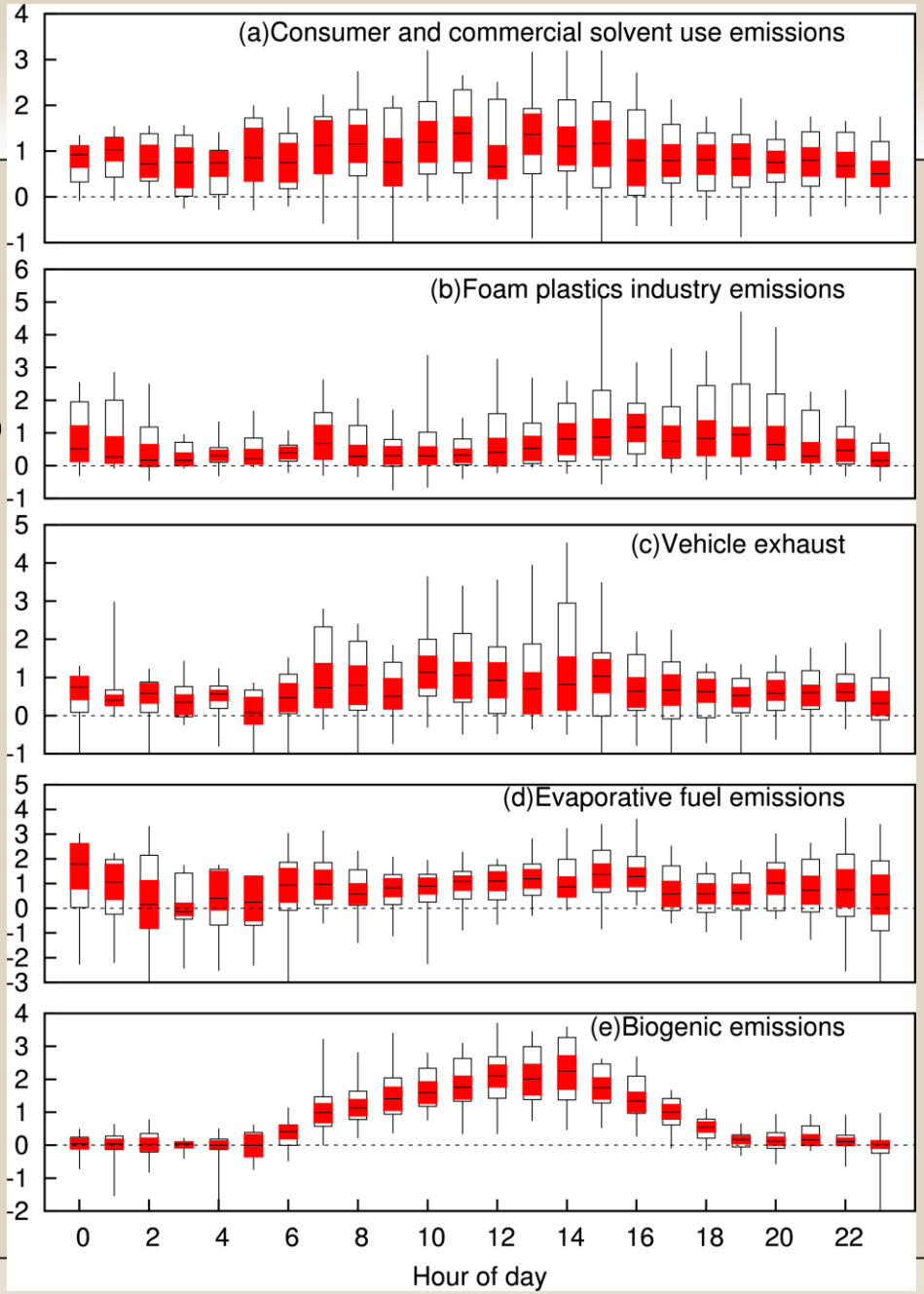
CO fluxes over time



VOC fluxes, I


Isopentane Vs Traffic Counts
Median Isopentane Flux (mg C m-2 hr-1)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
200
400
600
800
1000
1200
1400
All Median Half-Hour Traffic Counts
y = 0.0002x + 0.0495
R² = 0.9037
16:00 - 7:00
8:00 - 15:00

VOC fluxes, II



- ~~makeup, paint, etc.~~
- industry
- your car exhaust
- your (car) fuel leak(s)
- those pesky trees

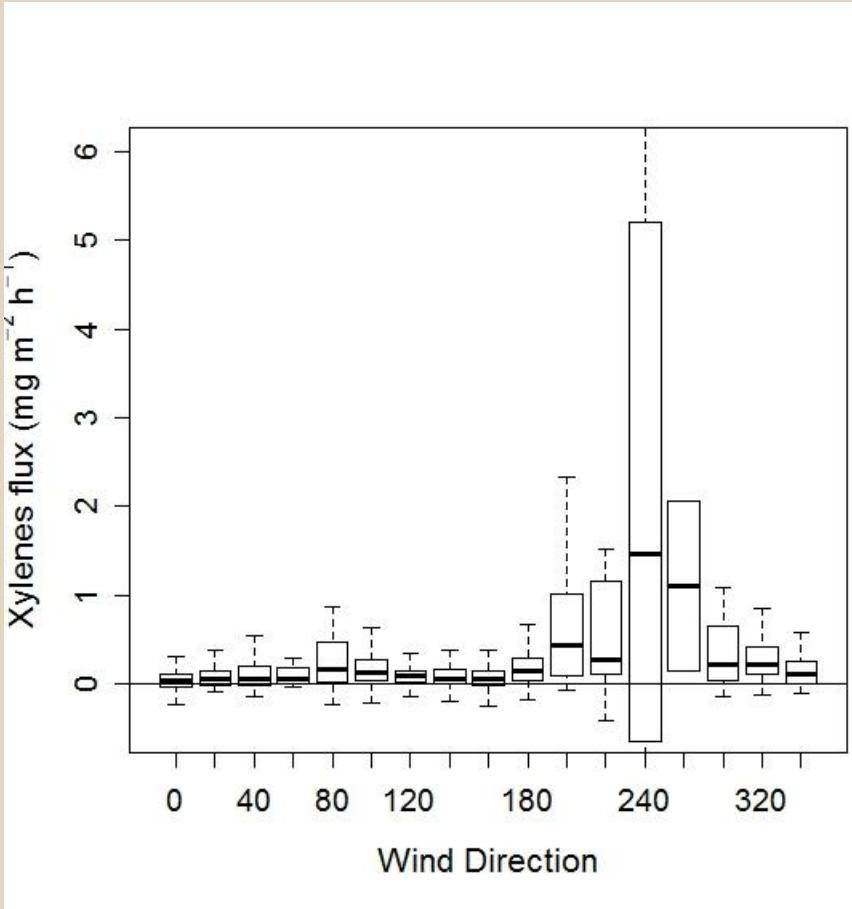
Kota et al., Atmos. Environ., 2013

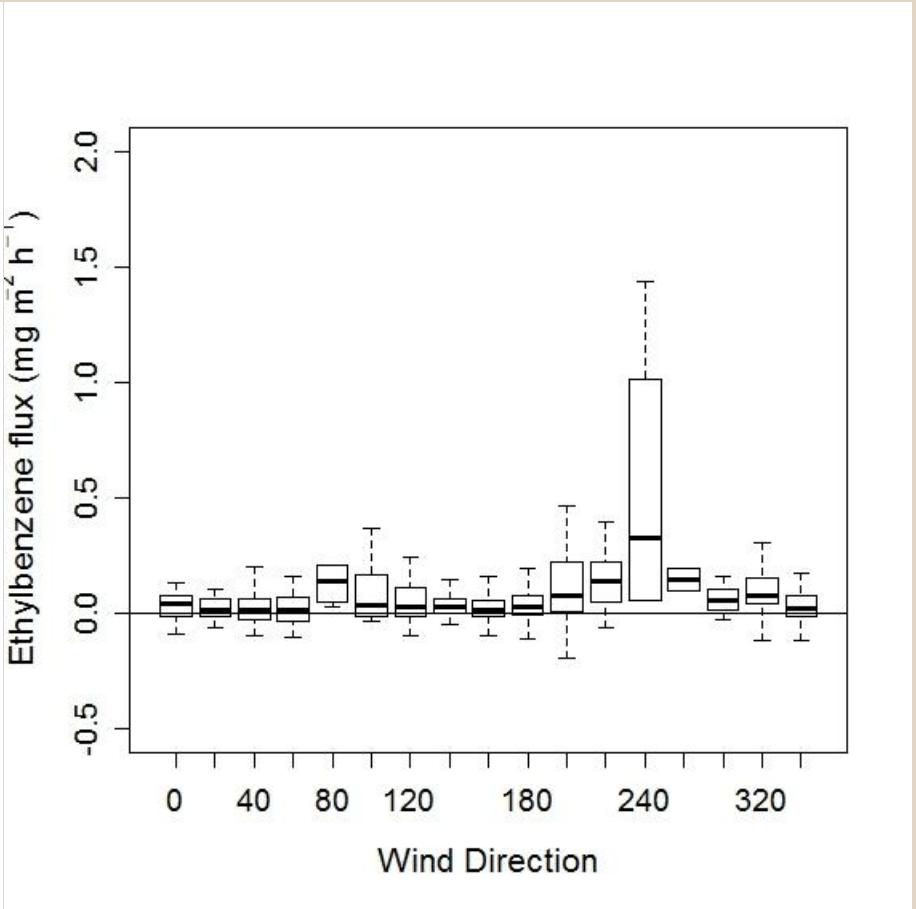
VOC fluxes over time

	Max.	Mean	Median	SD
Benzene				
Winter 2009	1.52	0.21	0.17	0.23
Winter 2012	1.34	0.07	0.06	
Spring 2013	2.28	0.09	0.08	0.16
4-year % Change	50%	-57%	-53%	
Toluene				
Winter 2009	4.54	0.35	0.24	0.47
Winter 2012	3.40	0.19	0.07	
Spring 2013	7.31	0.26	0.11	0.64
4-year % Change	61%	-26%	-54%	
Ethylbenzene				
Winter 2009	0.86	0.07	0.04	0.09
Winter 2012	0.84	0.03	0.02	0.12
Spring 2013	3.02	0.07	0.03	0.21
4-year % Change	251%	0%	25%	
Xylenes				
Winter 2009	4.33	0.23	0.14	0.35
Winter 2012	3.23	0.14	0.08	0.36
Spring 2013	10.85	0.23	0.10	0.66
4-year % Change	151%	0%	-40%	

VOC fluxes, III

Xylan© coating process facility, 200 m SSW of tower

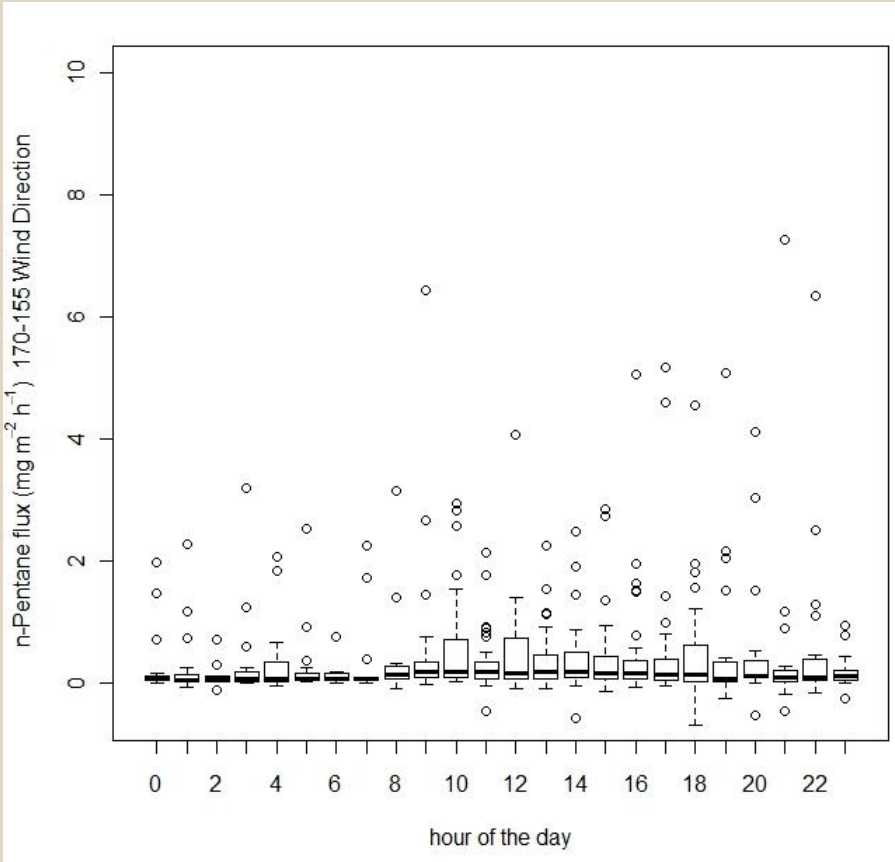




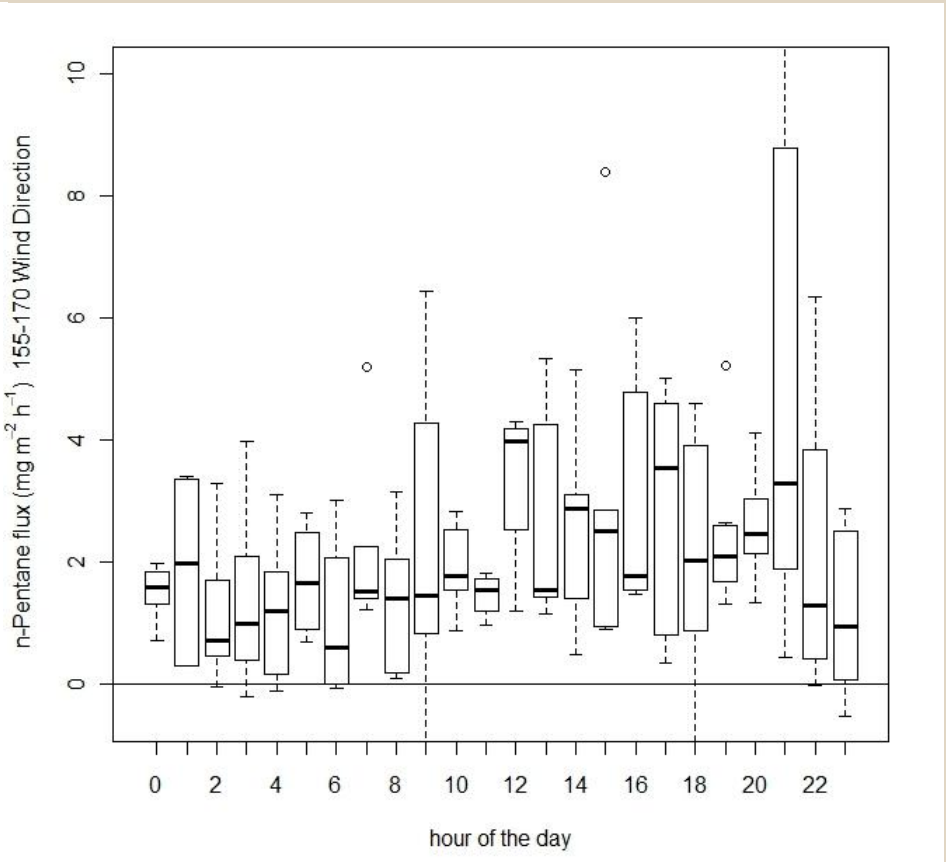
A Large Pentane Source, I

- **n-Pentane used as a blowing agent in polystyrene foam production**

wind not from source

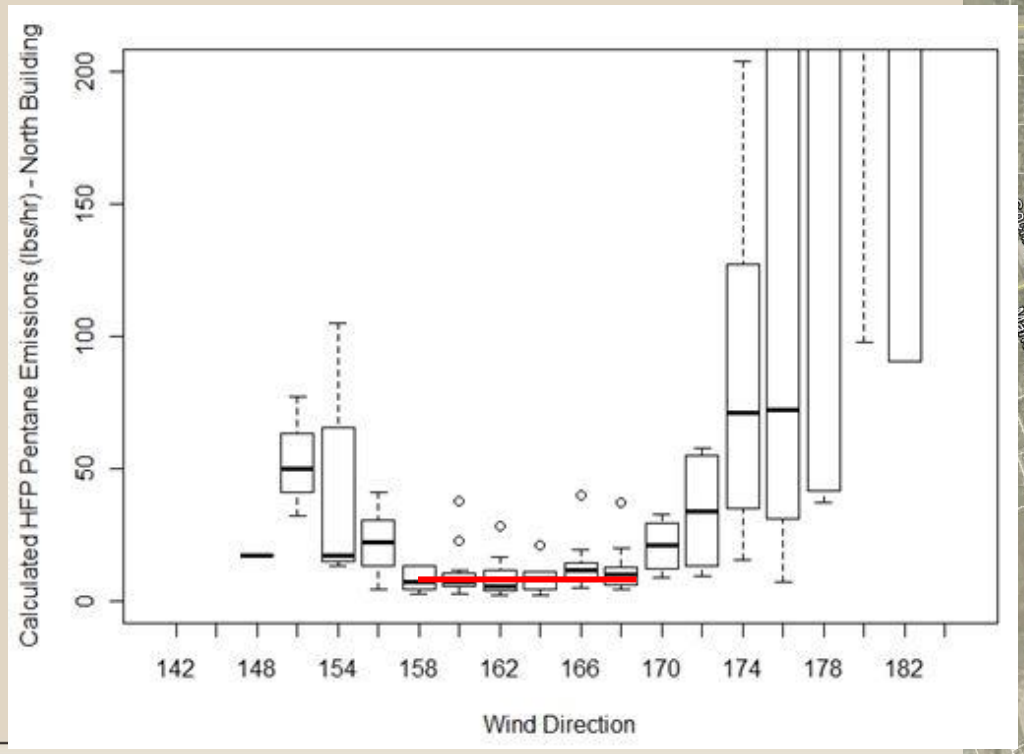


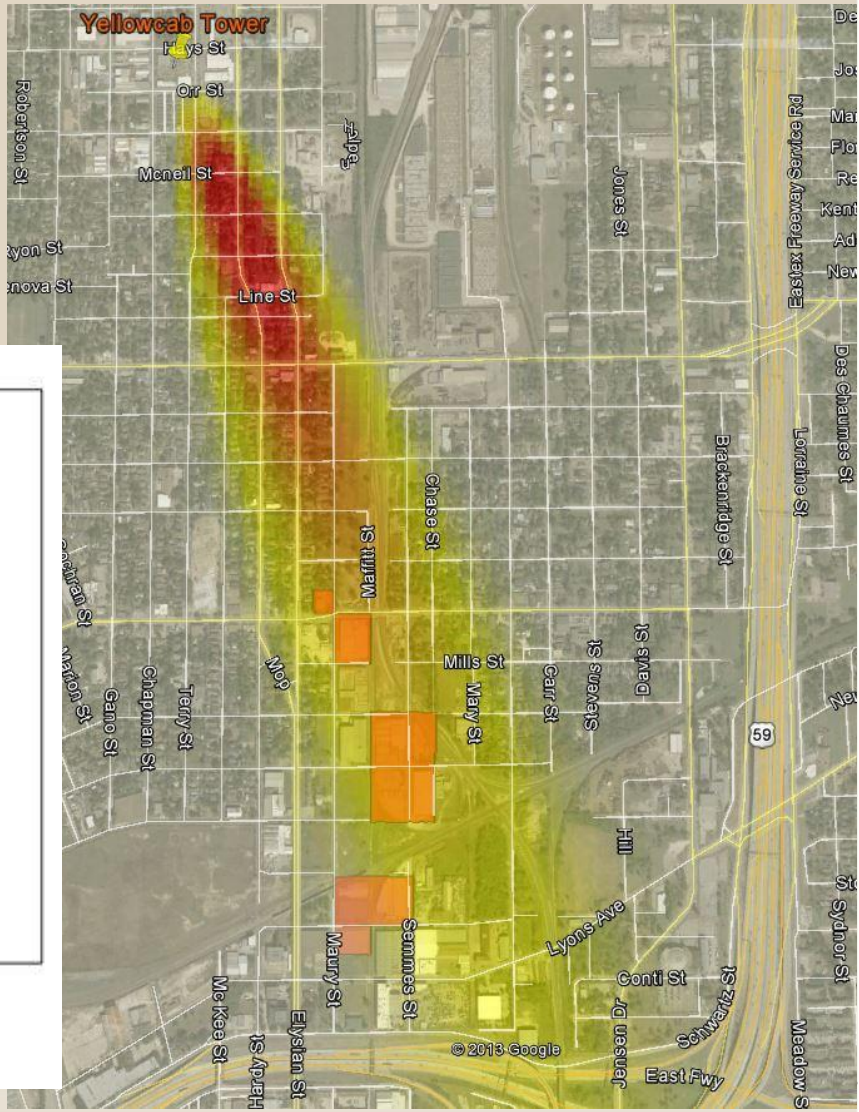
wind from pentane source



A Large Pentane Source, II

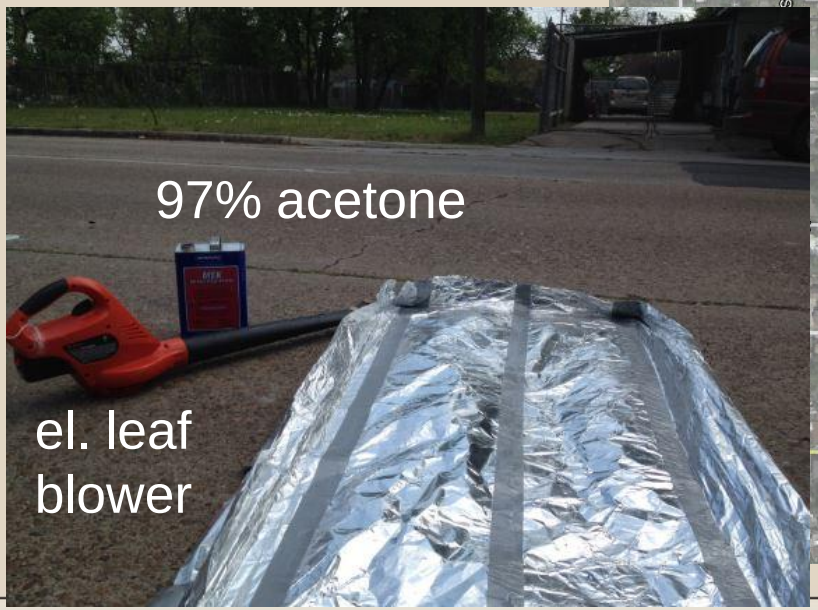
- emissions permit: 10-23 lbs/hr (mean-max)
- using footprint model and net flux corrected for background shows average and median emissions of 15.1 lbs/hr and 12.2 lbs/hr, respectively

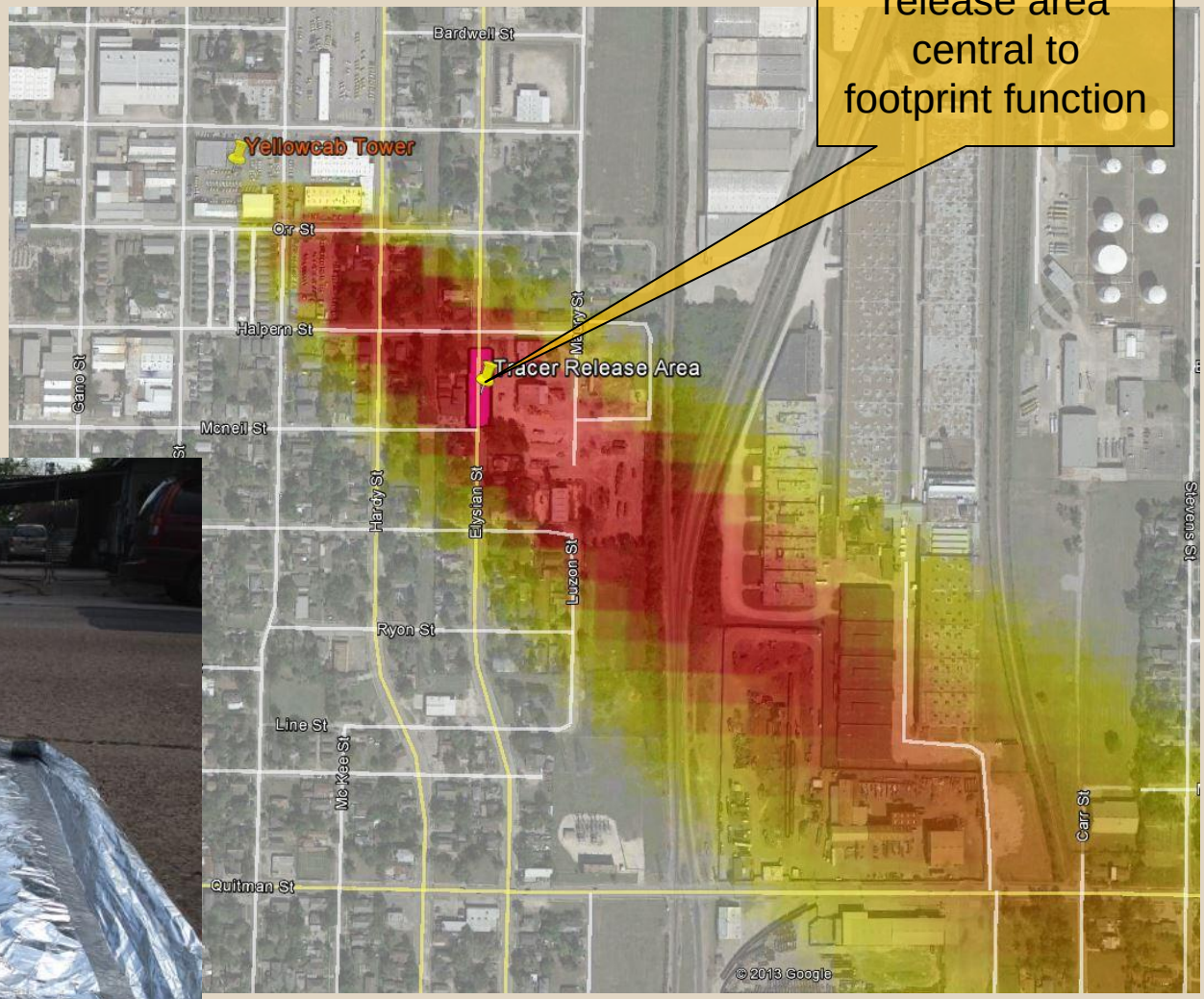




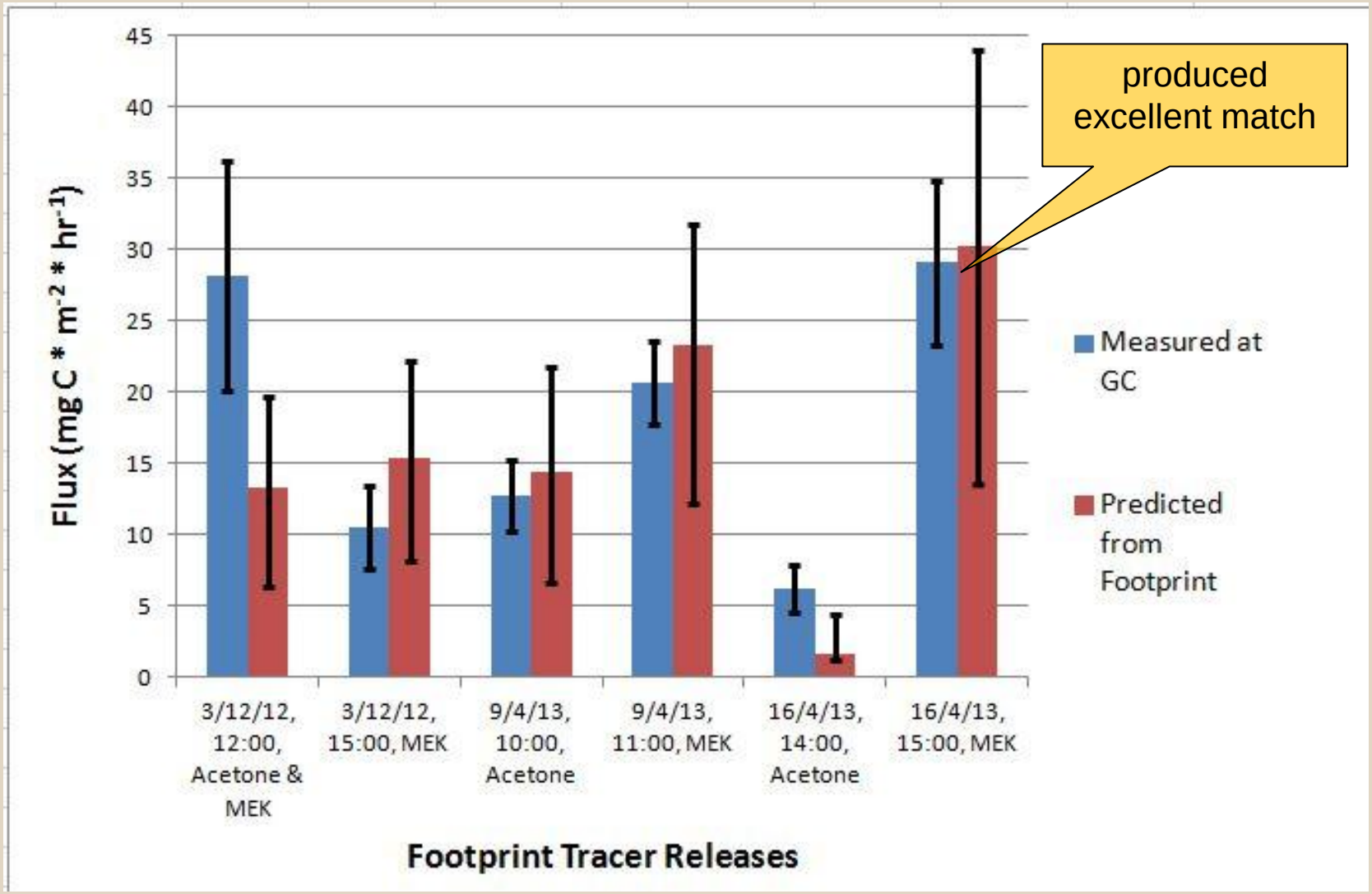
Tracer release study, I

- April 16, 2013 15:00 CDT release of 2 gallons of MEK via *pour and blow dry* evaporation method.





Tracer release study, II



Some Conclusions

- 4-5 years of useful CO_2, CO, and NO_x flux data
  - available for model comparisons
  - 2007/08/09 net CO_2 fluxes in Ameriflux data base
  - CO fluxes used independently to scale traffic contribution
    - no consistent trend in measured CO fluxes though
- unique seasonal VOC flux data
  - clear reductions over 4-yr period
  - used to carry out successful tracer release study
  - can monitor individual sources
  - can distinguish between sources
- bulk flux footprint model reasonably reliable
  - within factor of 2 when overlapping source; many uncertainties
  - biased when edge of footprint function overlaps source