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Improving Emission Inventories Using Direct Flux Measurements and Modeling

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EPA webinar, 17 July 2017

Acknowledgements

Houston Yellow Cab

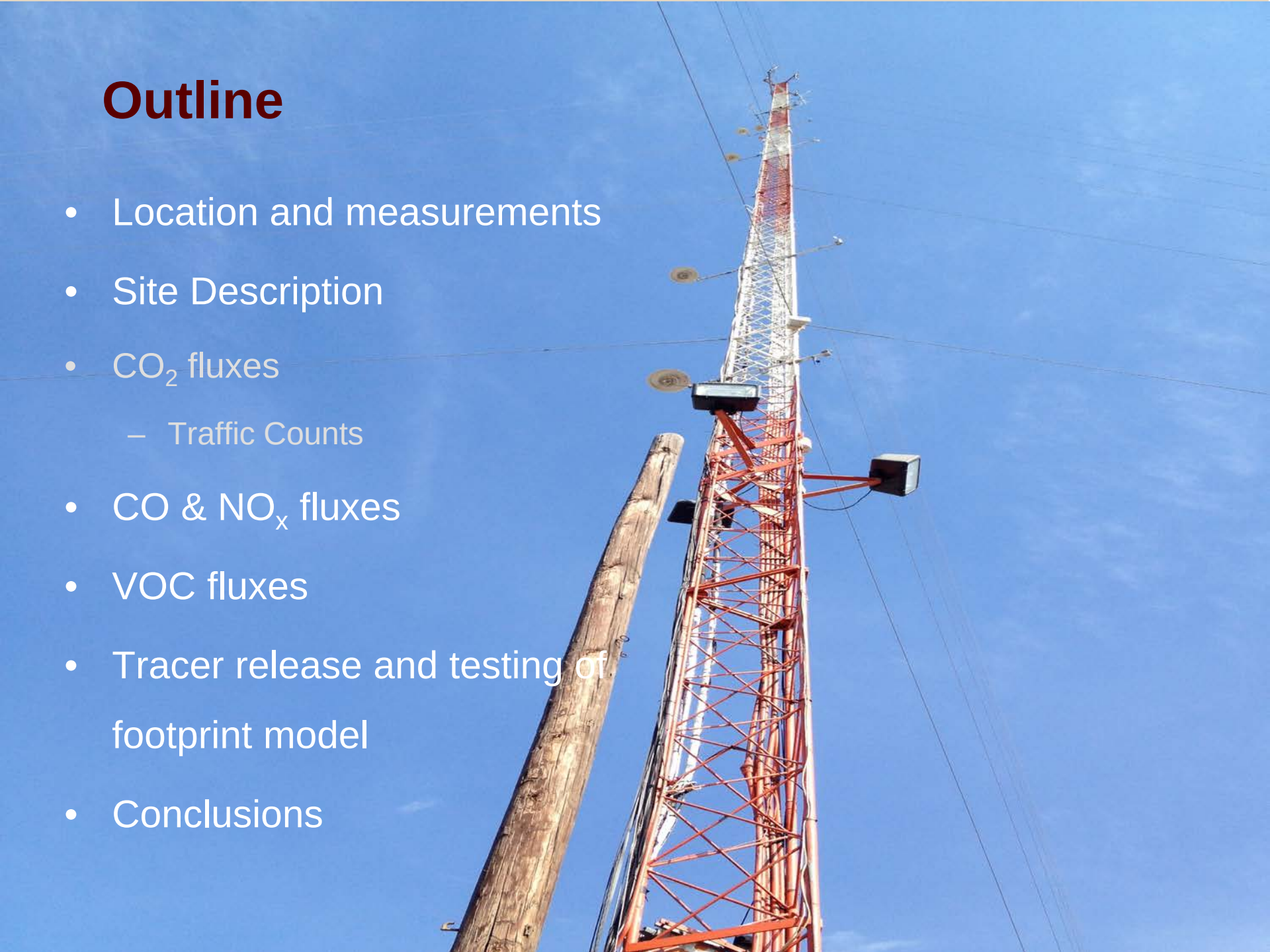
TARC (establishing the site, VOCs)

EPA-STAR (criteria pollutants & VOCs)

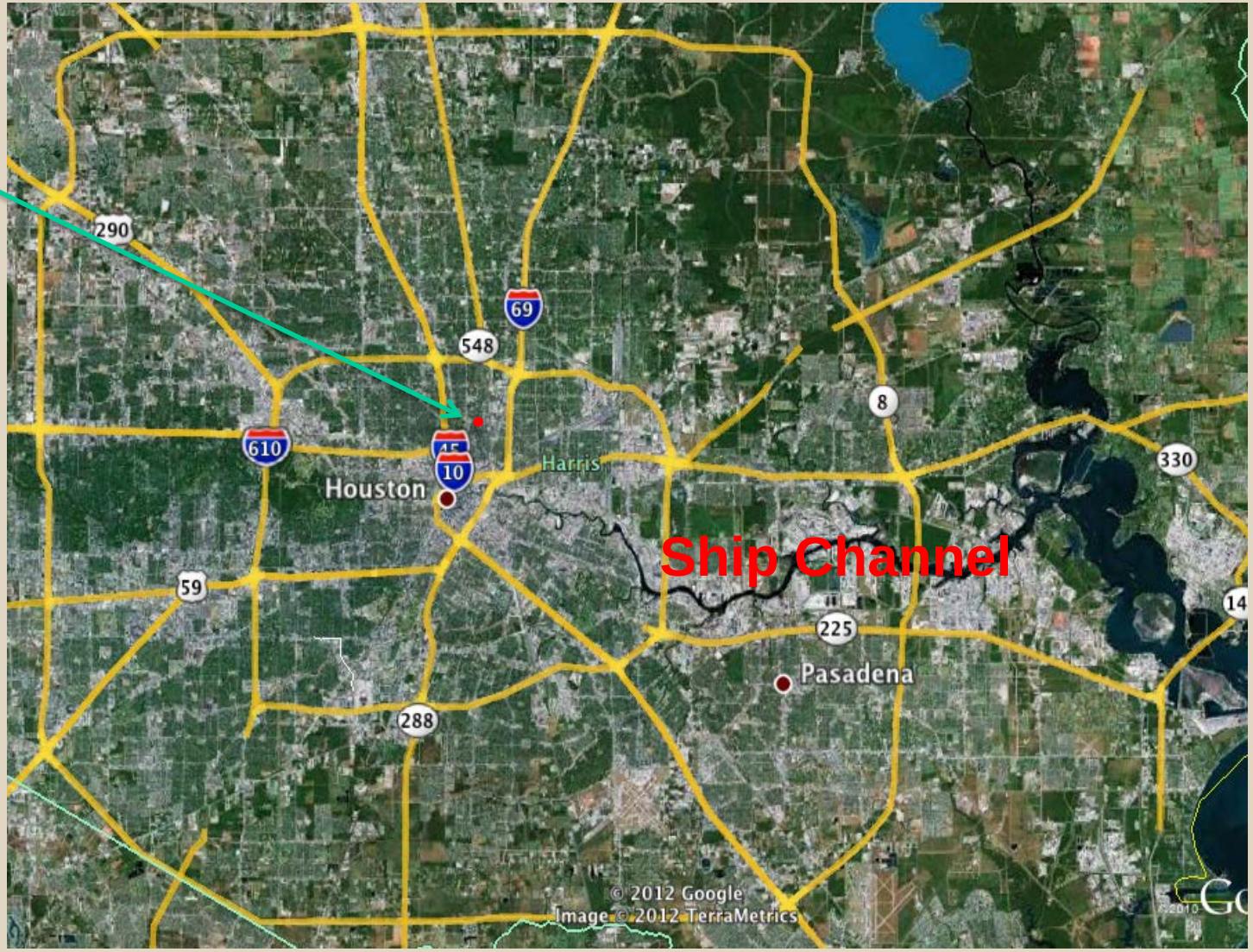
NOAA-GCC (carbon fluxes)

Outline

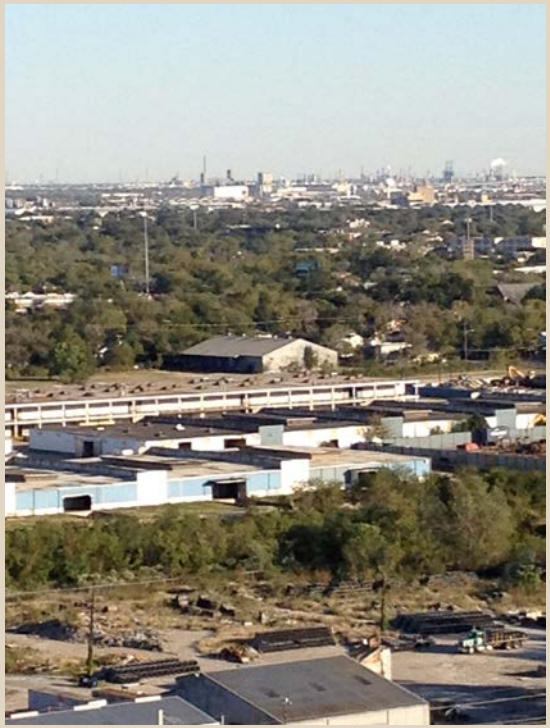
- Location and measurements
- Site Description
- CO_2 fluxes
  - Traffic Counts
- CO & NO_x fluxes
- VOC fluxes
- Tracer release and testing of footprint model
- Conclusions



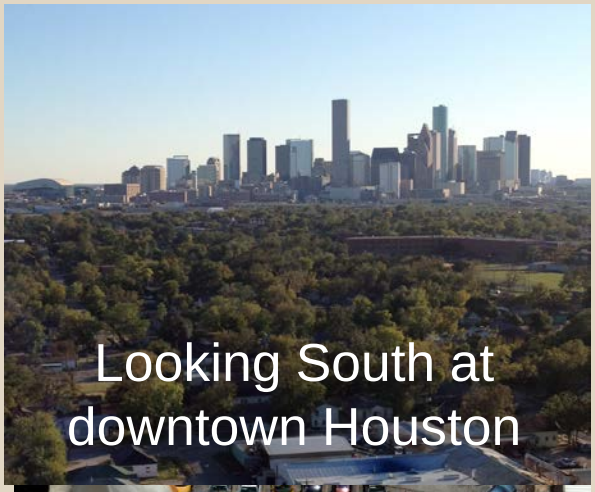
Site Description, I



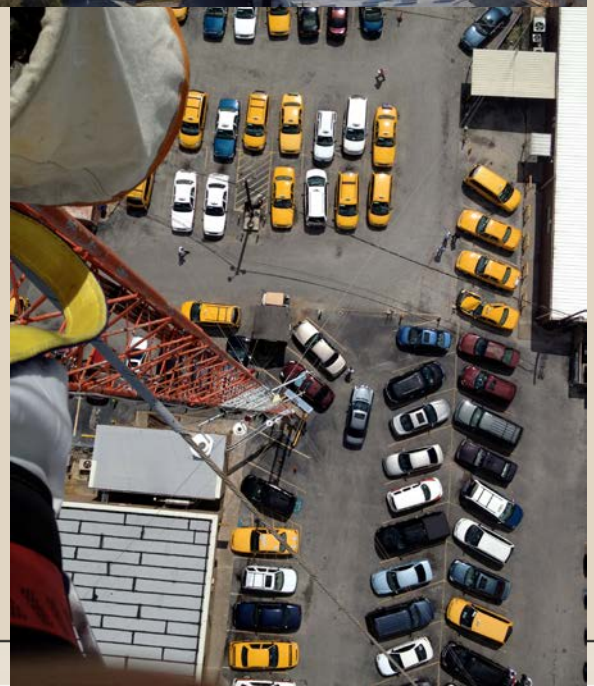
Views From the Sampling Point on the Tower



Looking ESE at the ship channel refineries

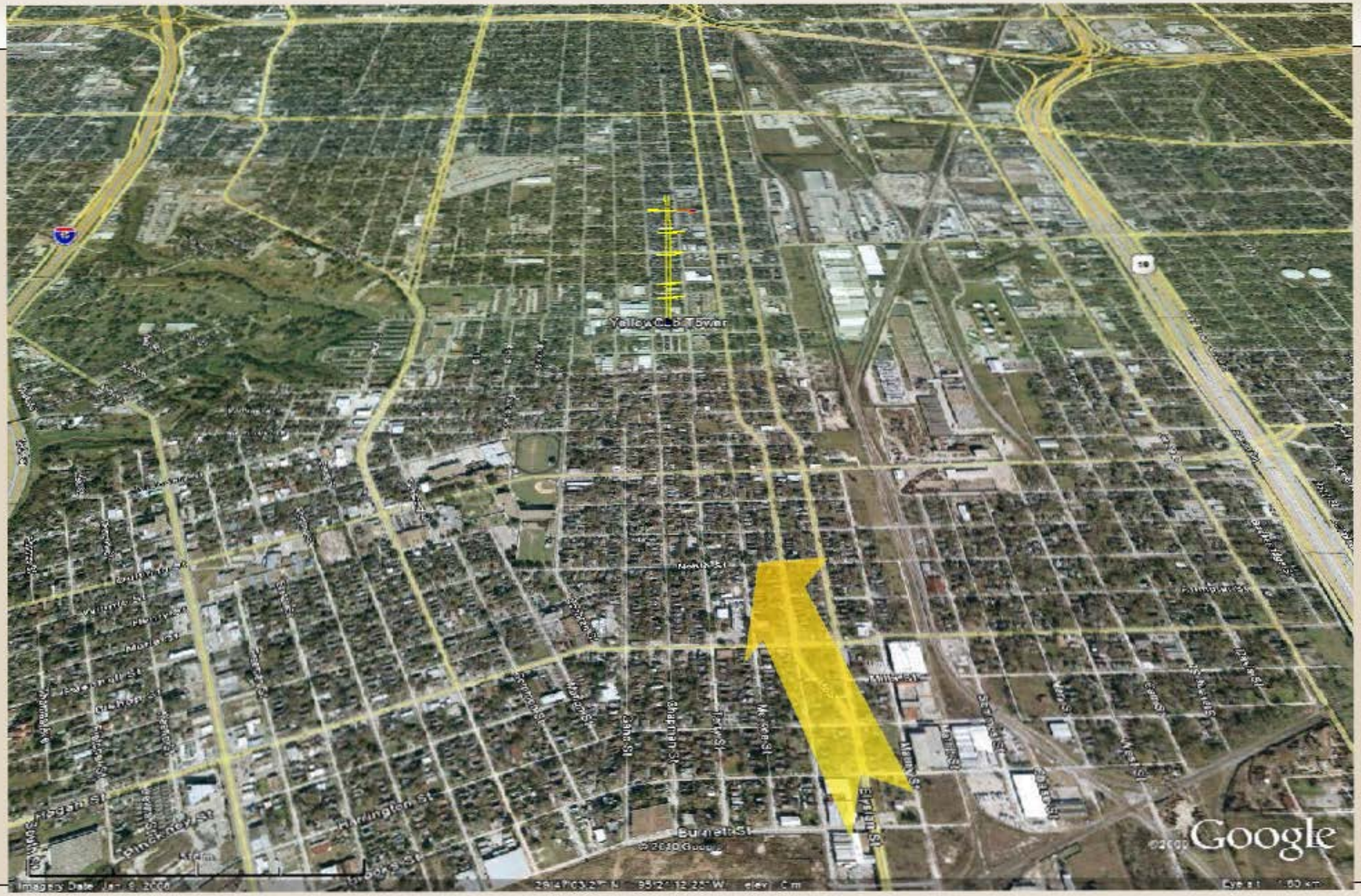


Looking South at downtown Houston

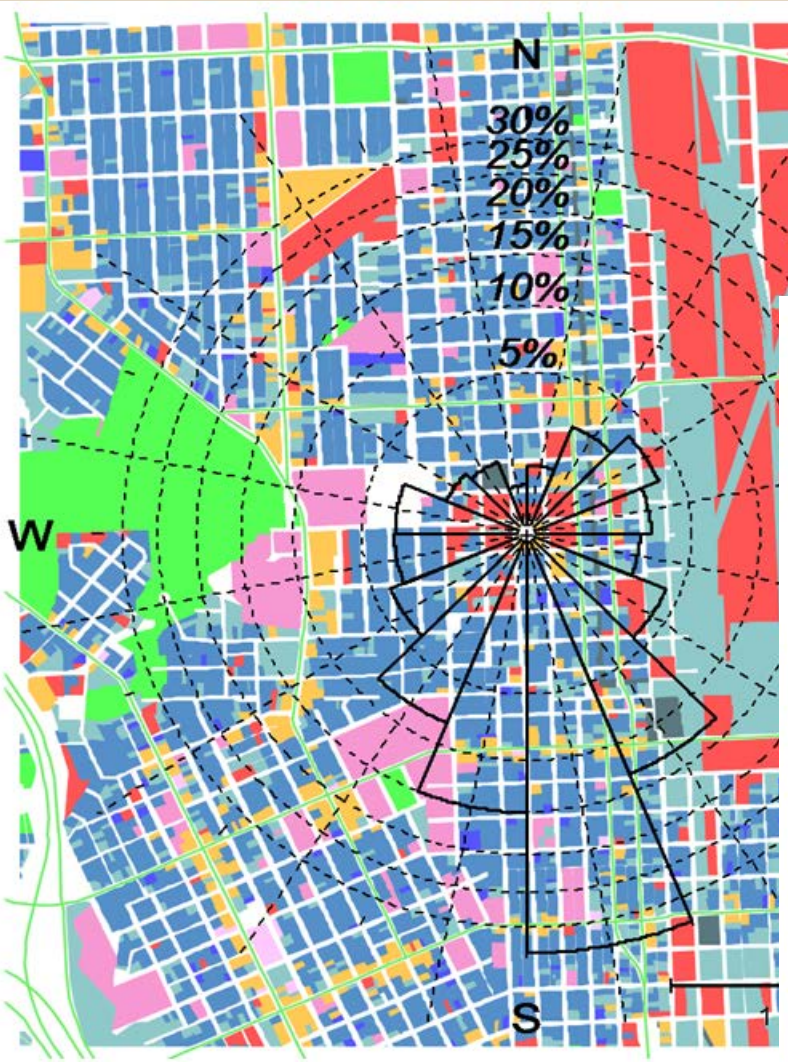


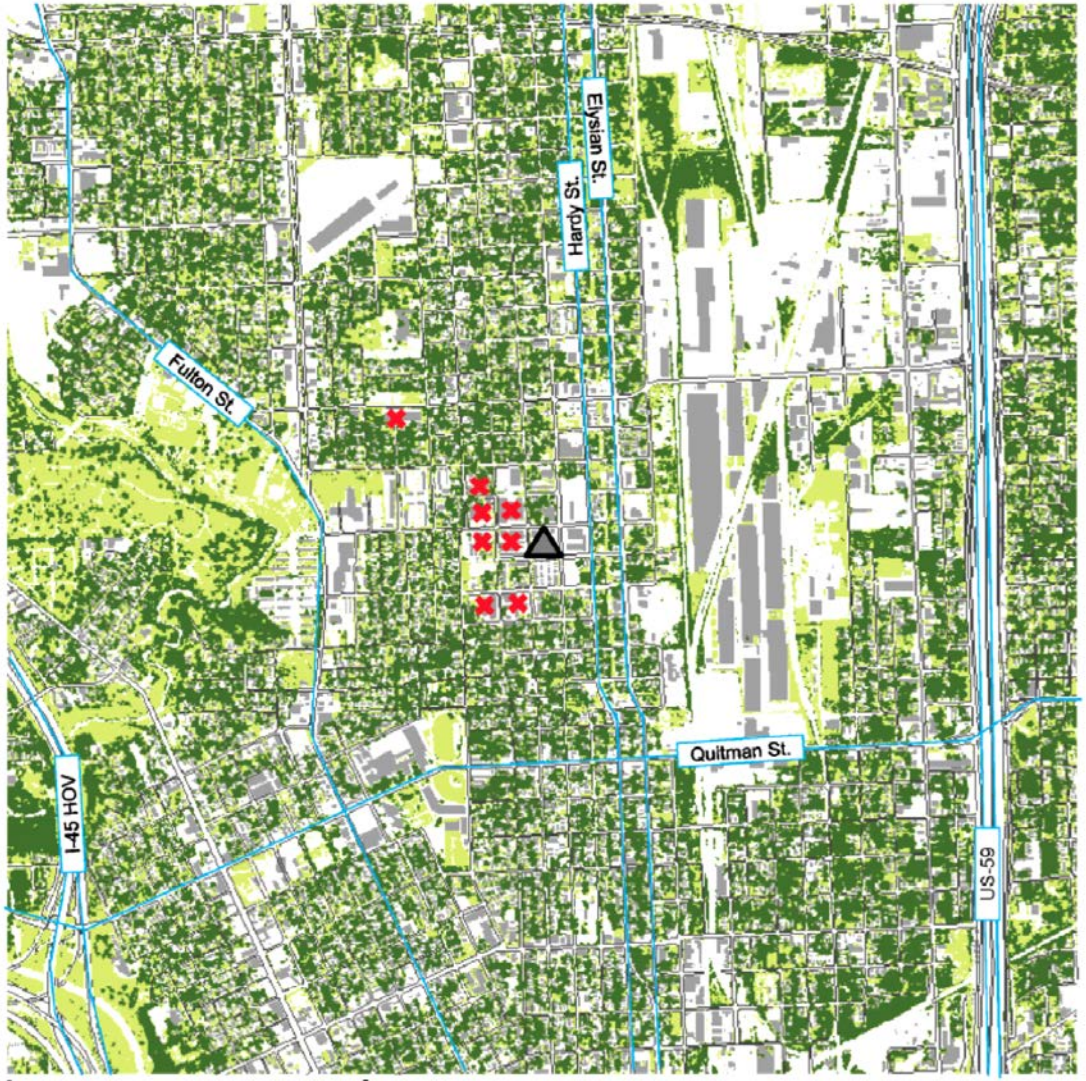
Looking WSW at the Galleria area

Site Description, II



land use

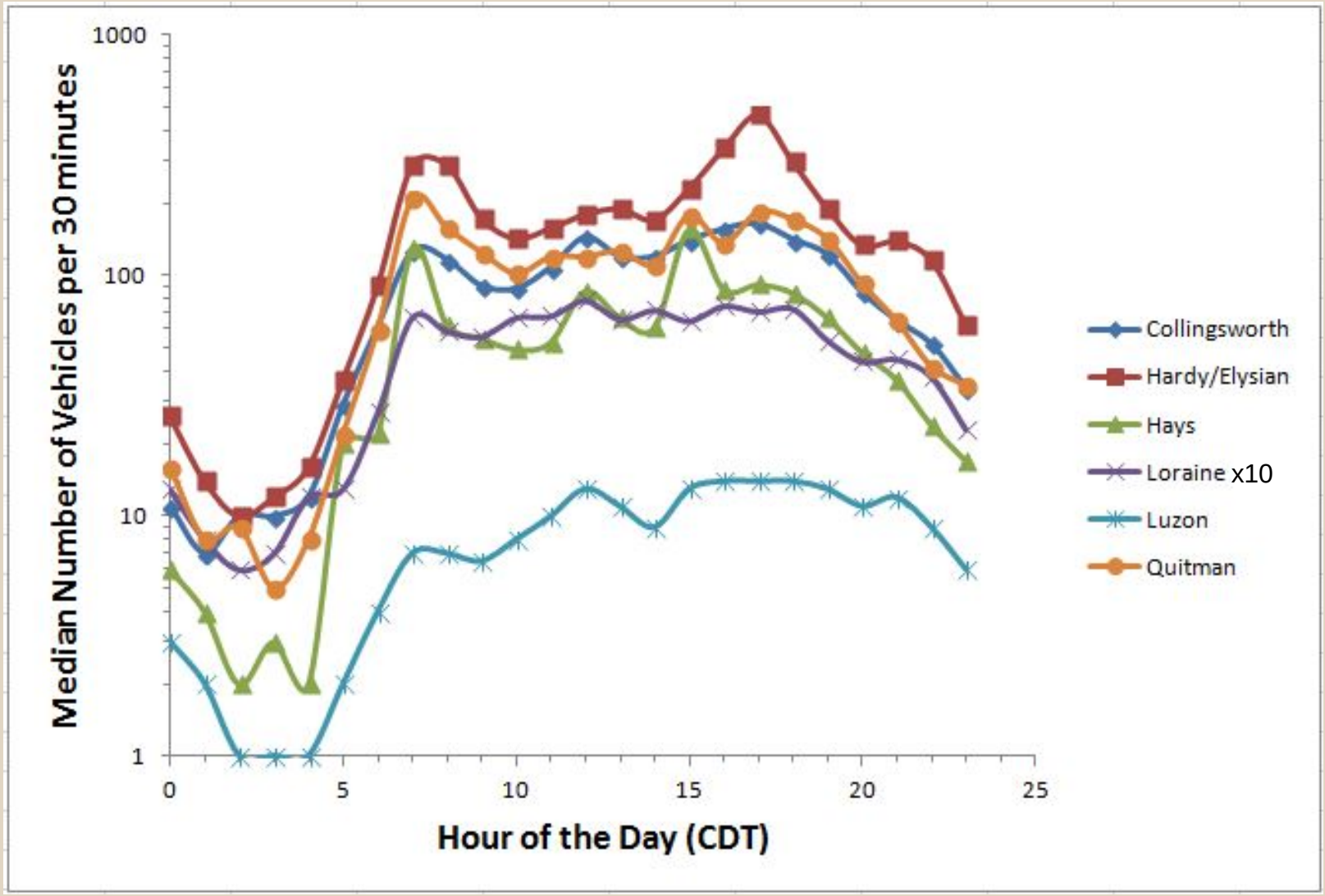




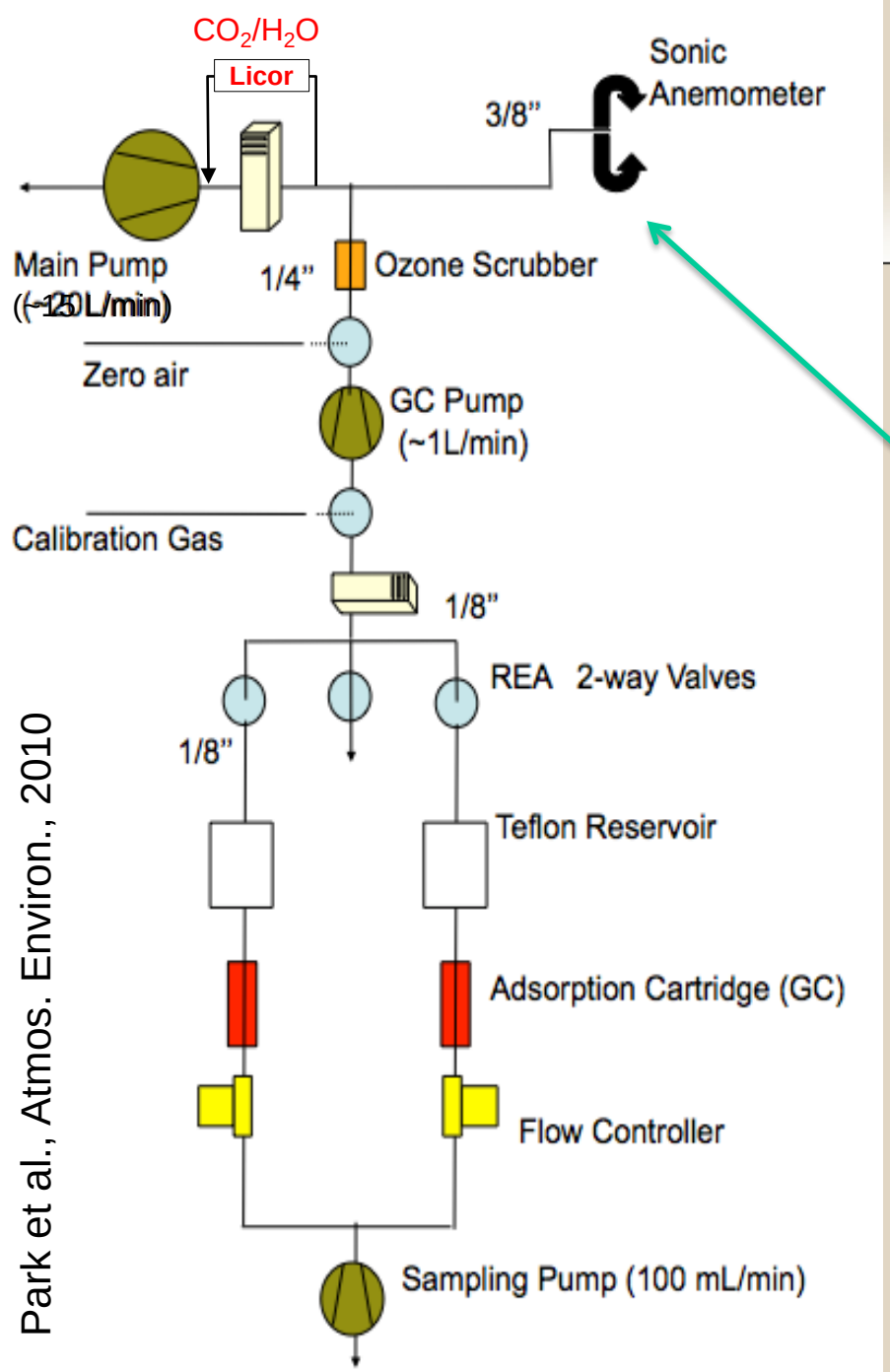
- Residential area
- Industrial area
- Commercial area
- Public/institutional area
- Park and open space
- Undeveloped land
- Roads

- Tree Crown
- Grass
- Building Block
- Edge of Pavement
- Main Road
- Flux Tower
- Small Industrial Company

Traffic counts

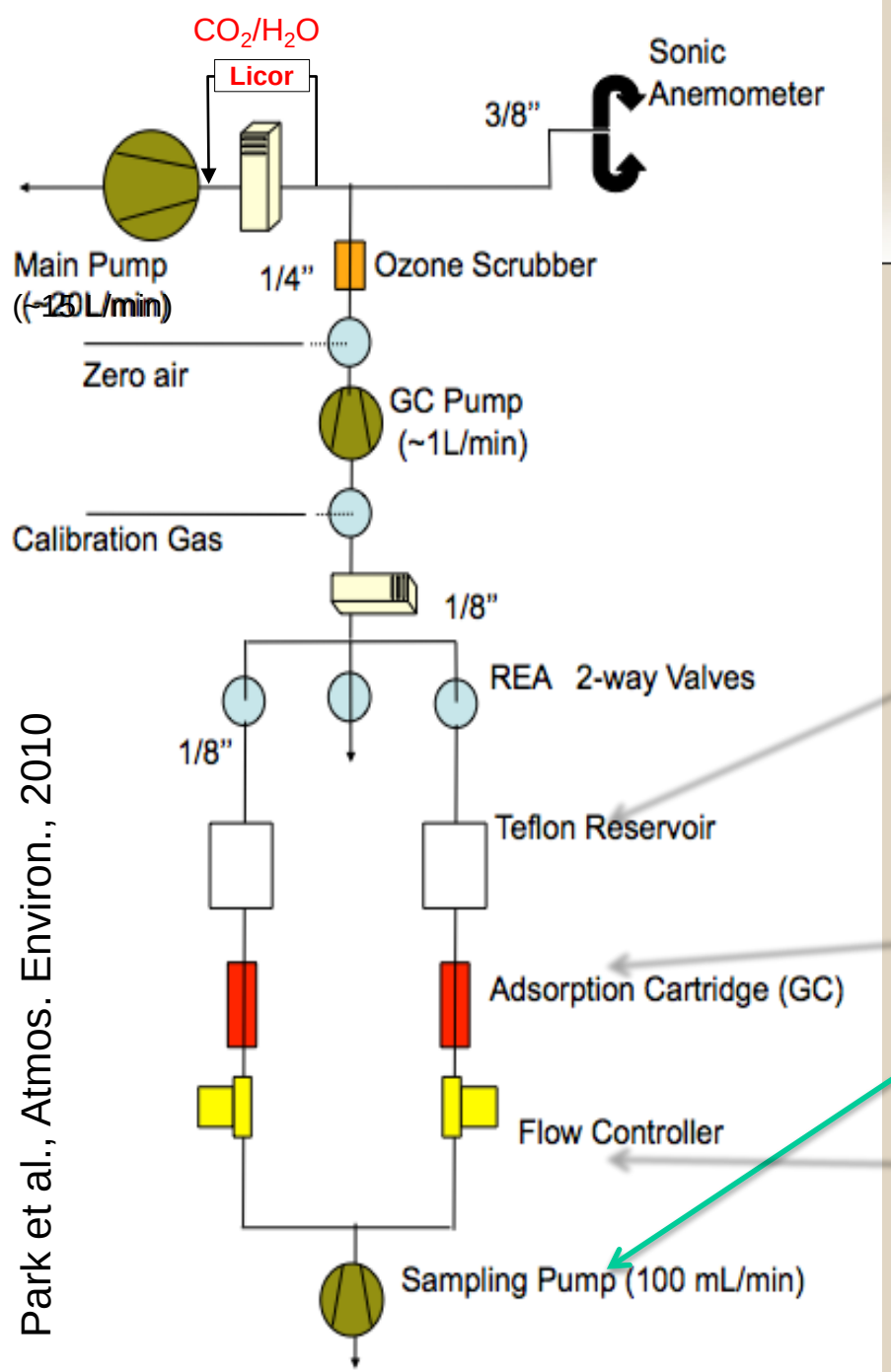


Setup

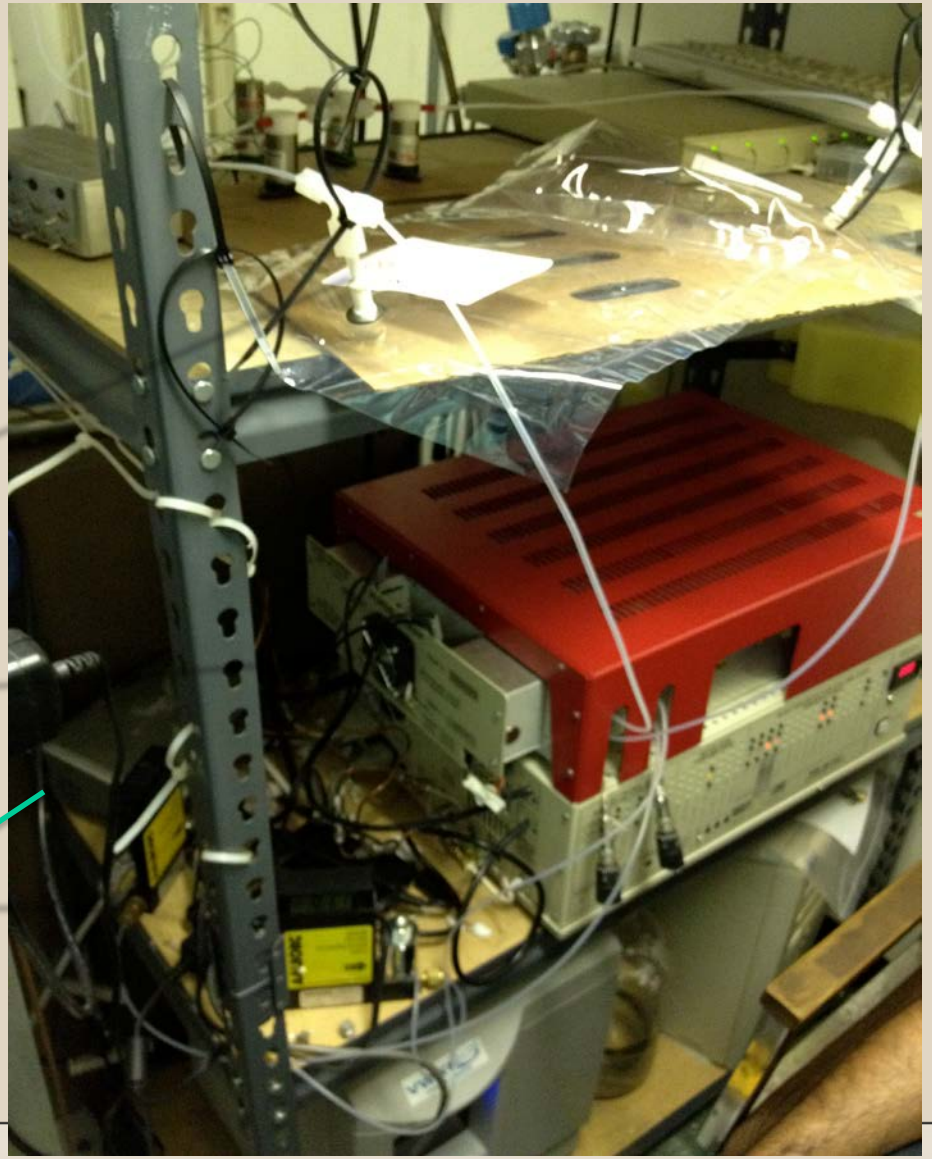


Park et al., Atmos. Environ., 2010

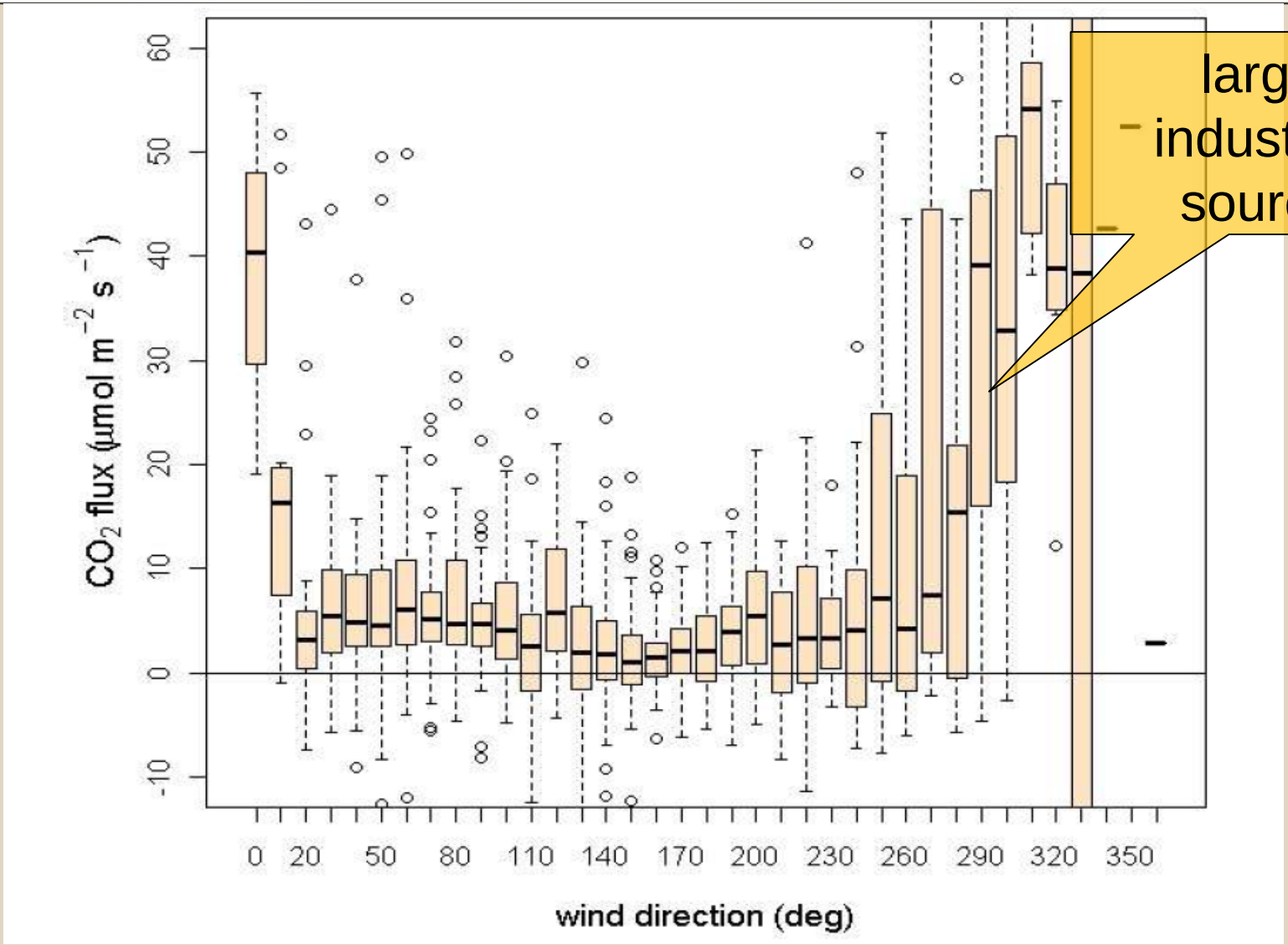
Setup



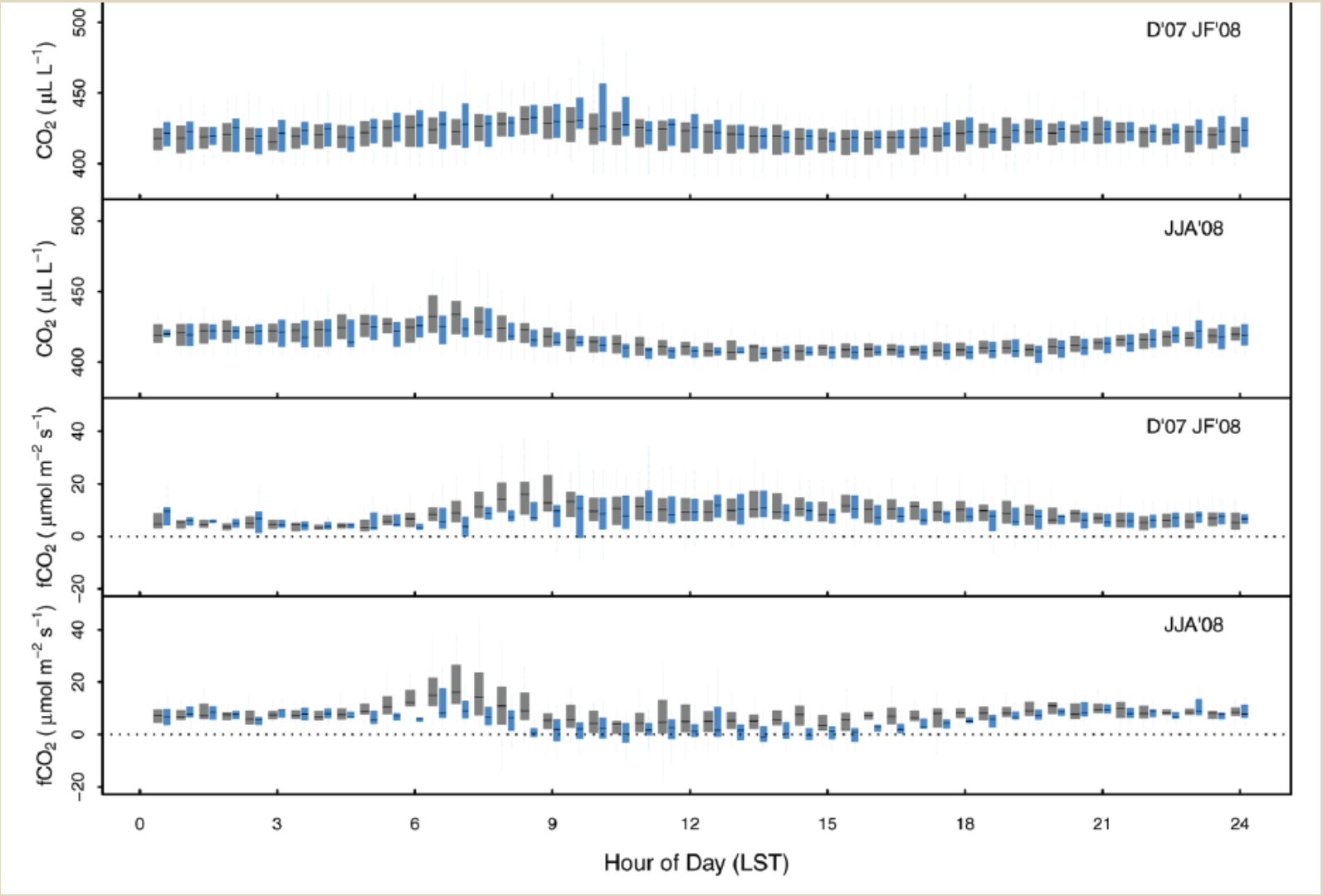
Park et al., Atmos. Environ., 2010



CO_2 fluxes, I

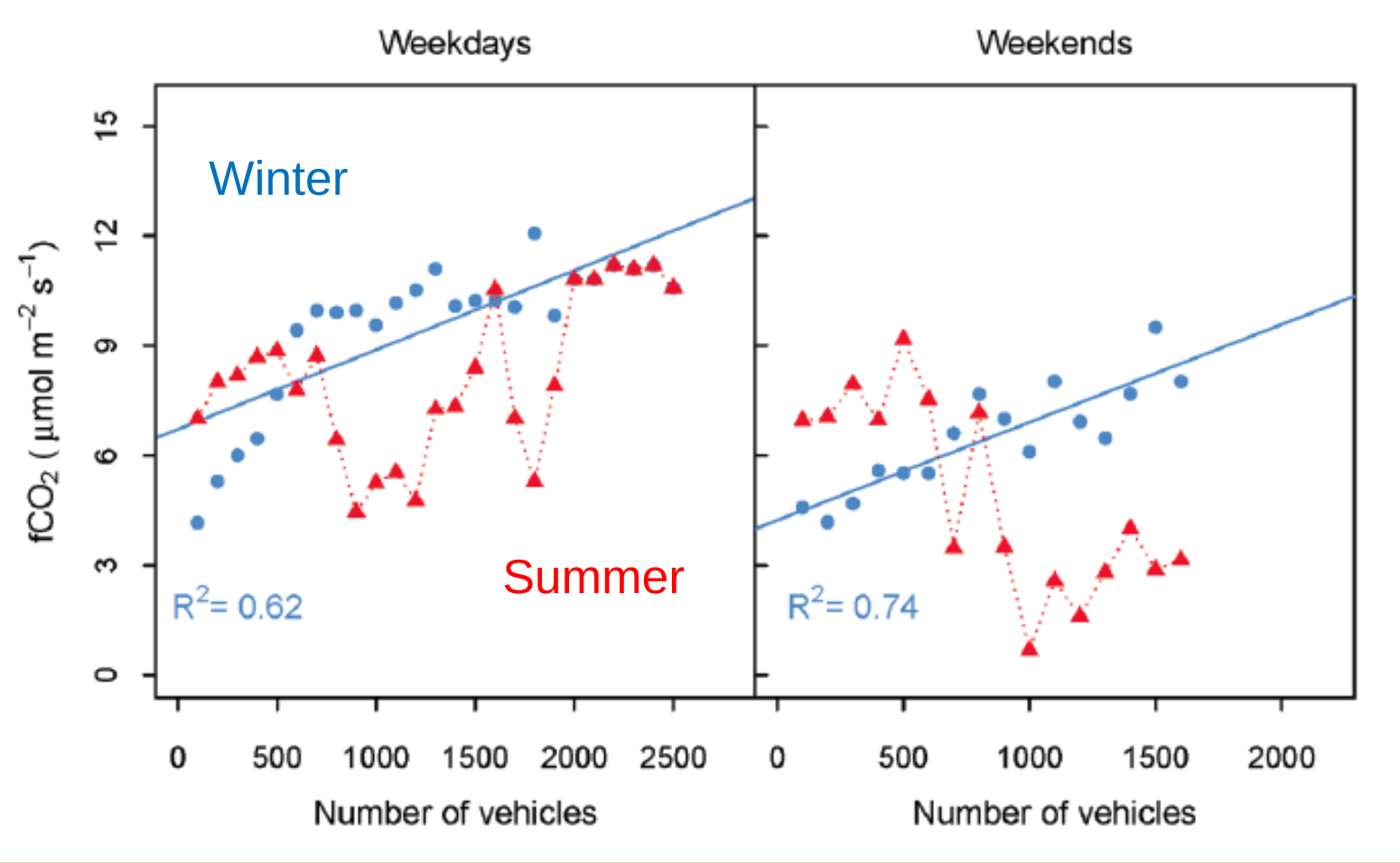

large
industrial
source
CO_2 flux (μmol m^{-2} s^{-1})
-10
0
10
20
30
40
50
60
0
20
50
80
110
140
170
200
230
260
290
320
350
wind direction (deg)

CO_2 fluxes, II



Park and Schade, Atmos. Environ., JEQ 2016

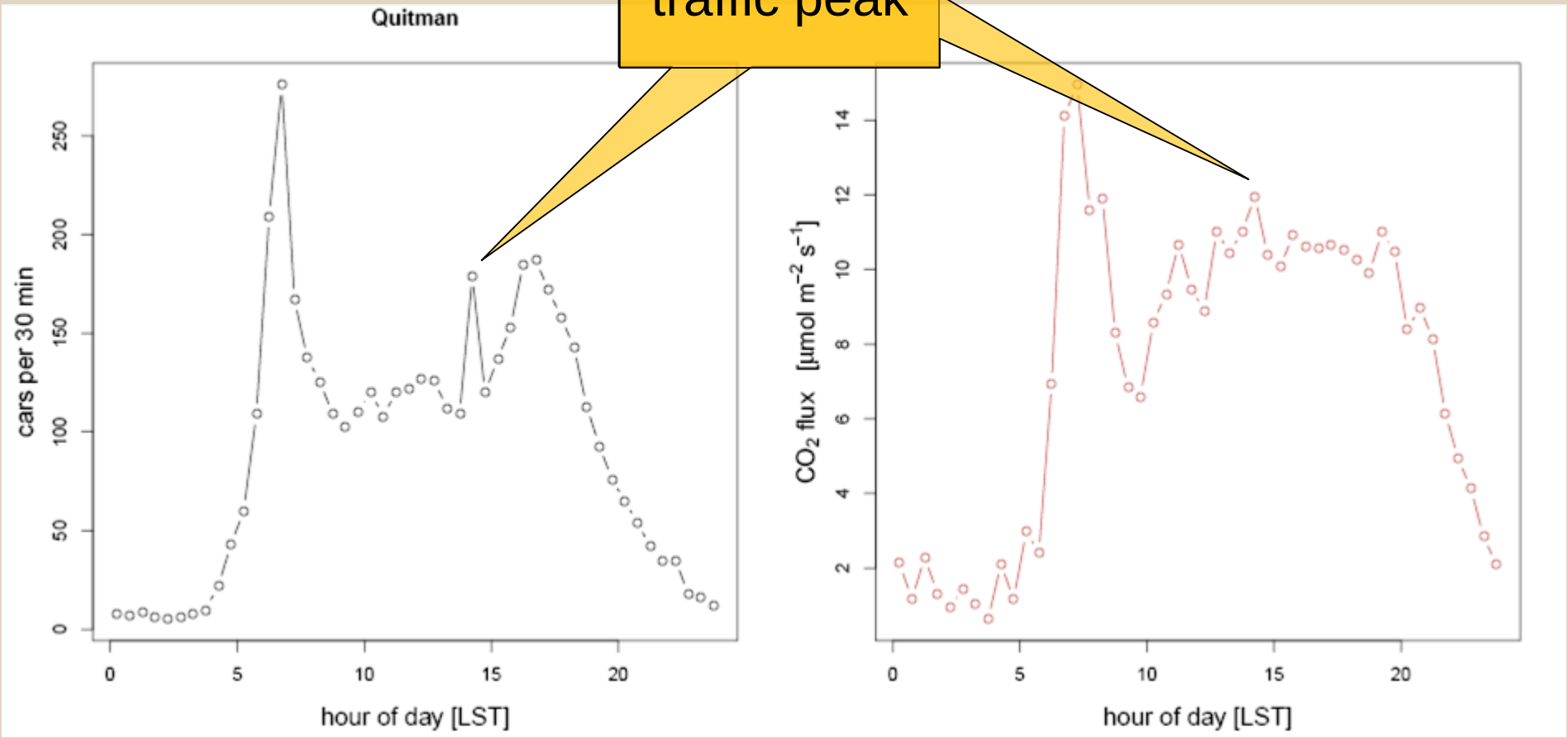
CO_2 fluxes, III



Park and Schade, Atmos. Environ., JEQ 2016

CO_2 fluxes, IV

School traffic peak

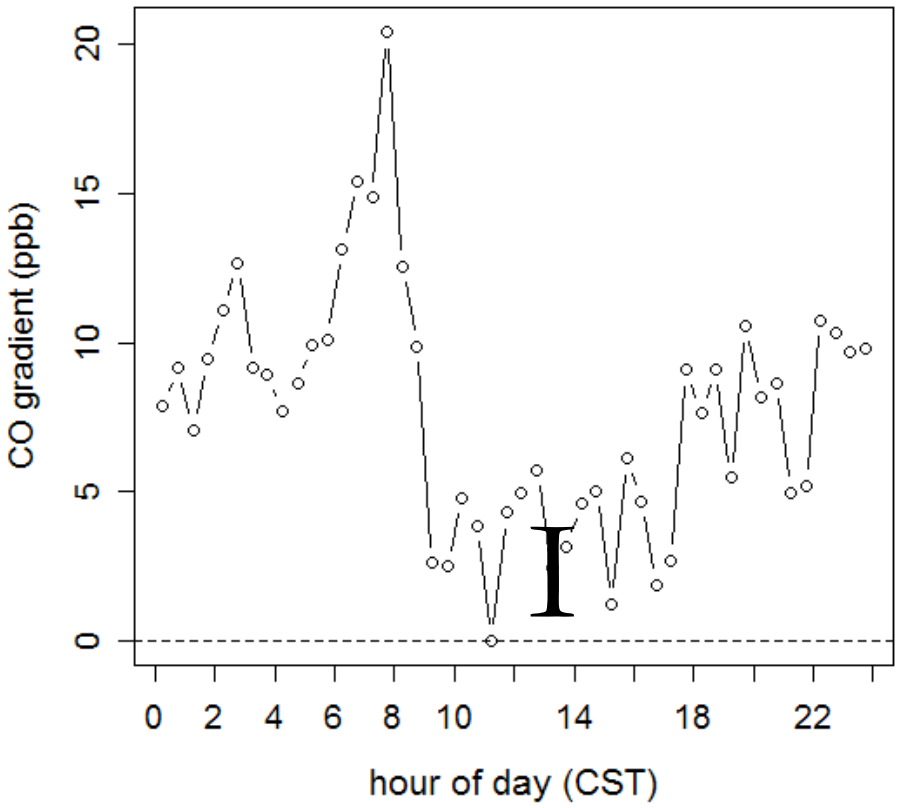


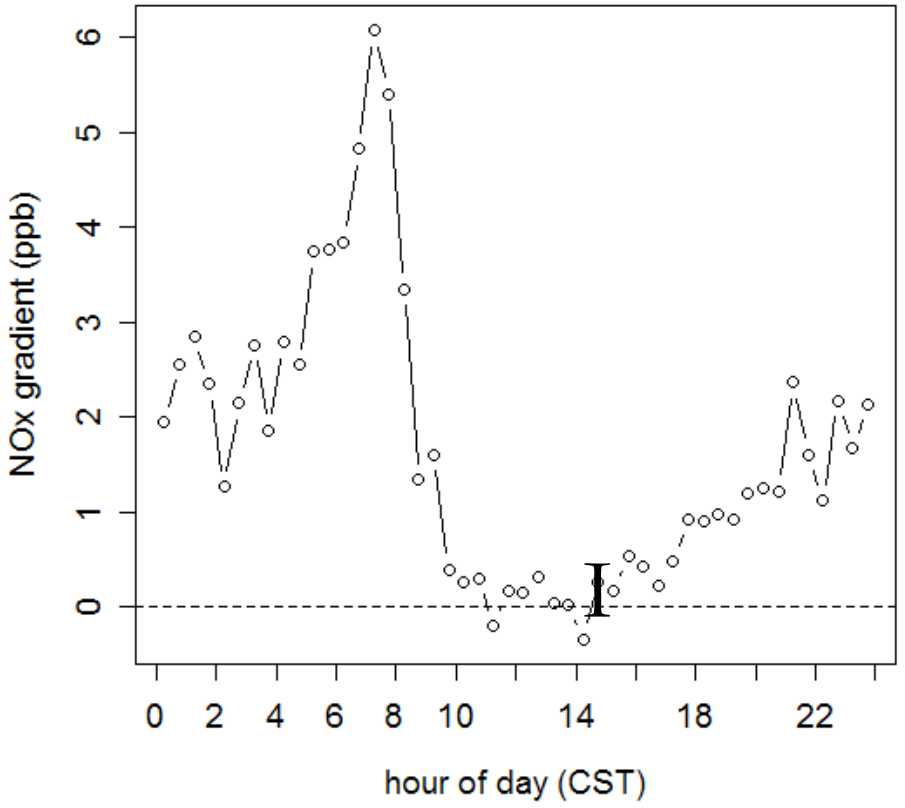
Anthropogenic CO_2-flux = 10 µmol m^{-2} s^{-1}

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

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

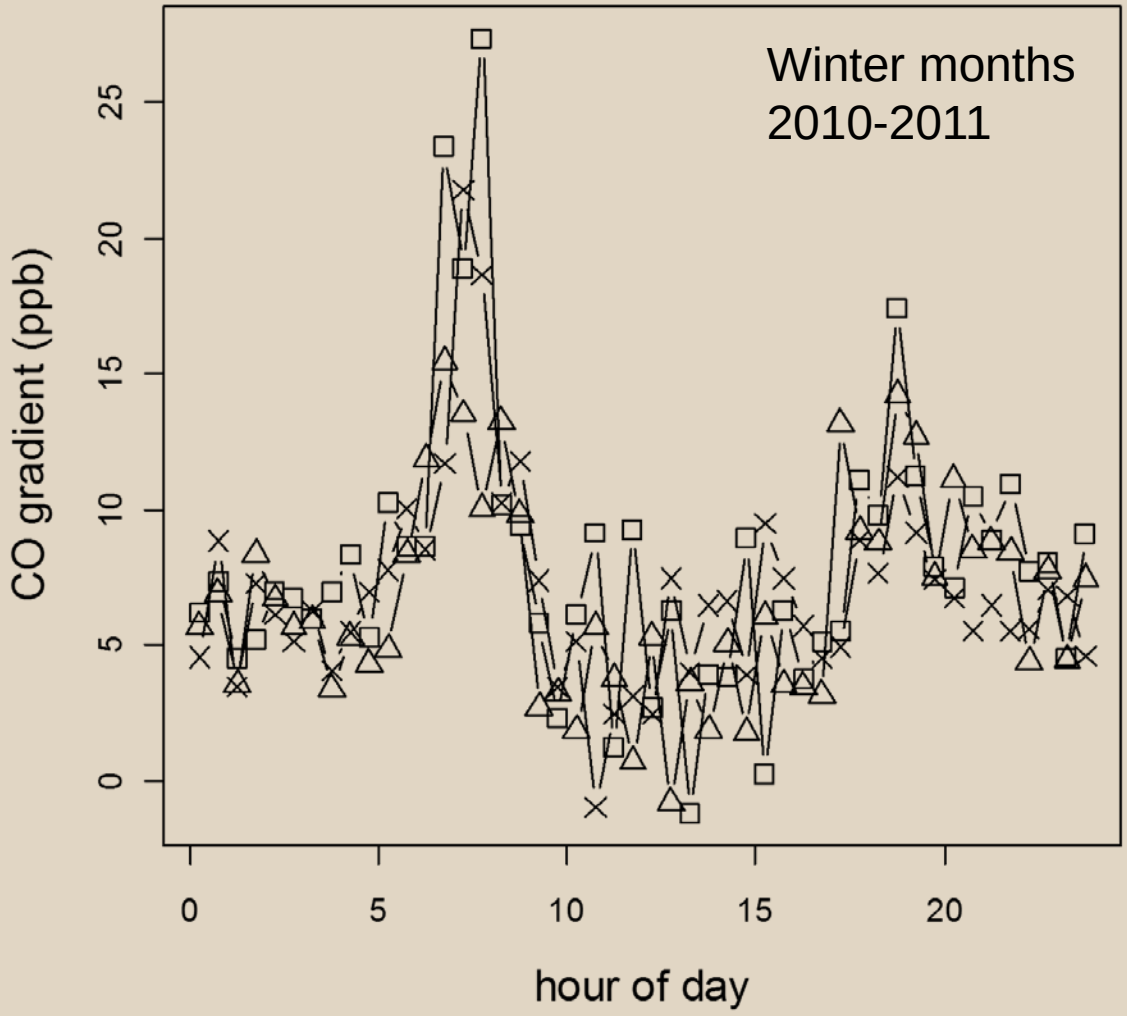
Criteria Pollutant Fluxes, I



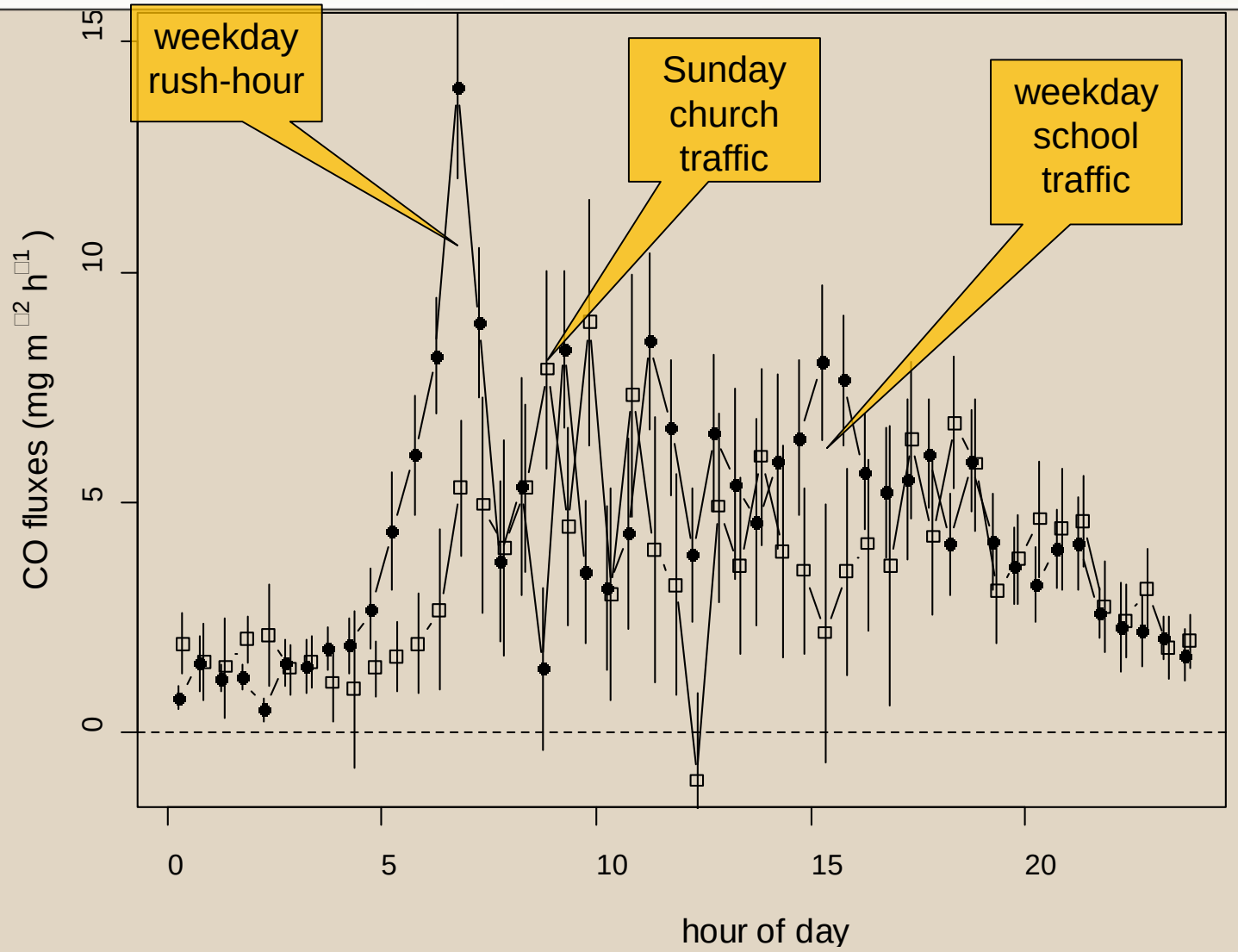


monthly, half-hourly median 20-m gradients

Criteria Pollutant Fluxes, II

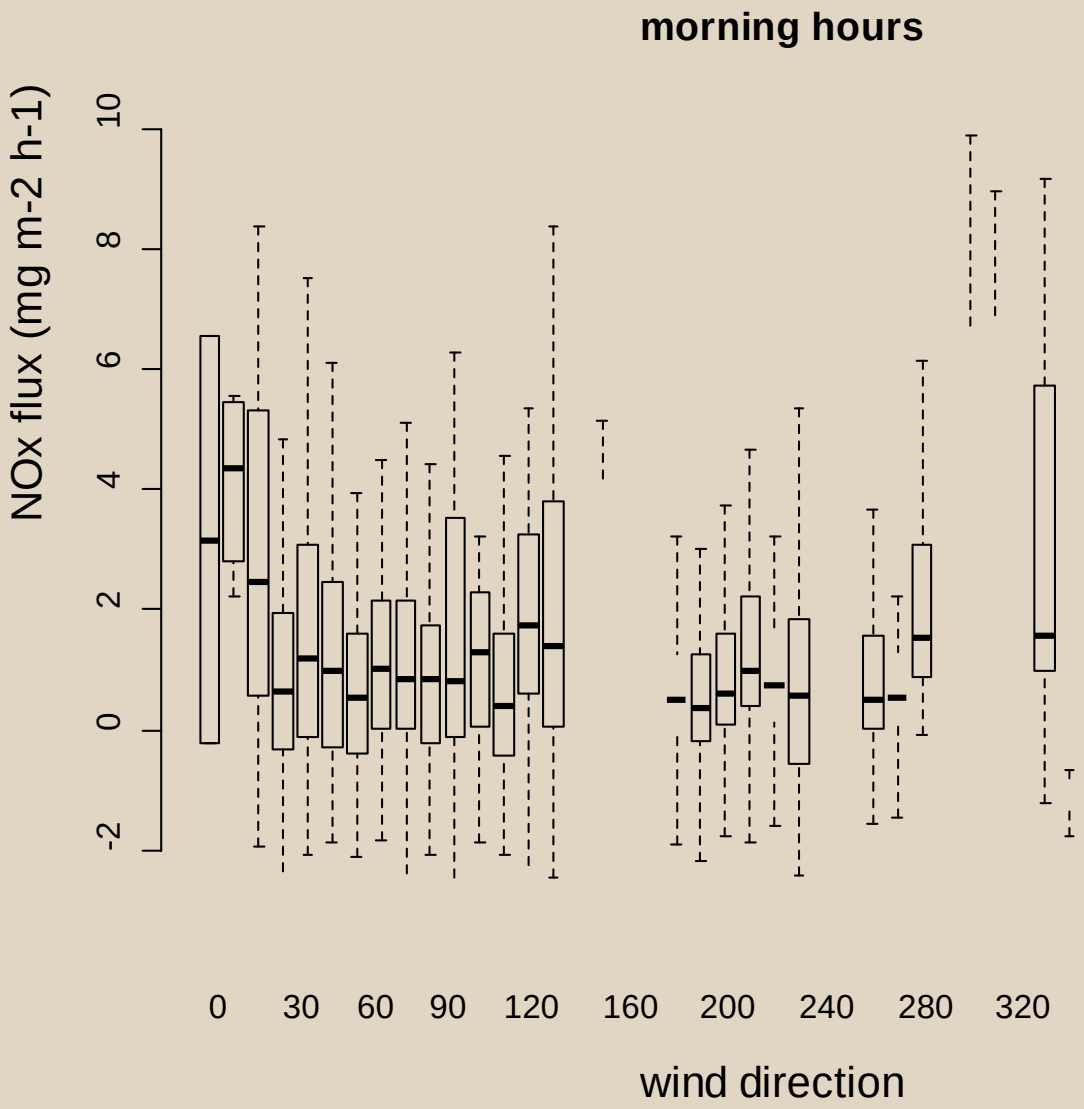


Criteria Pollutant Fluxes, III



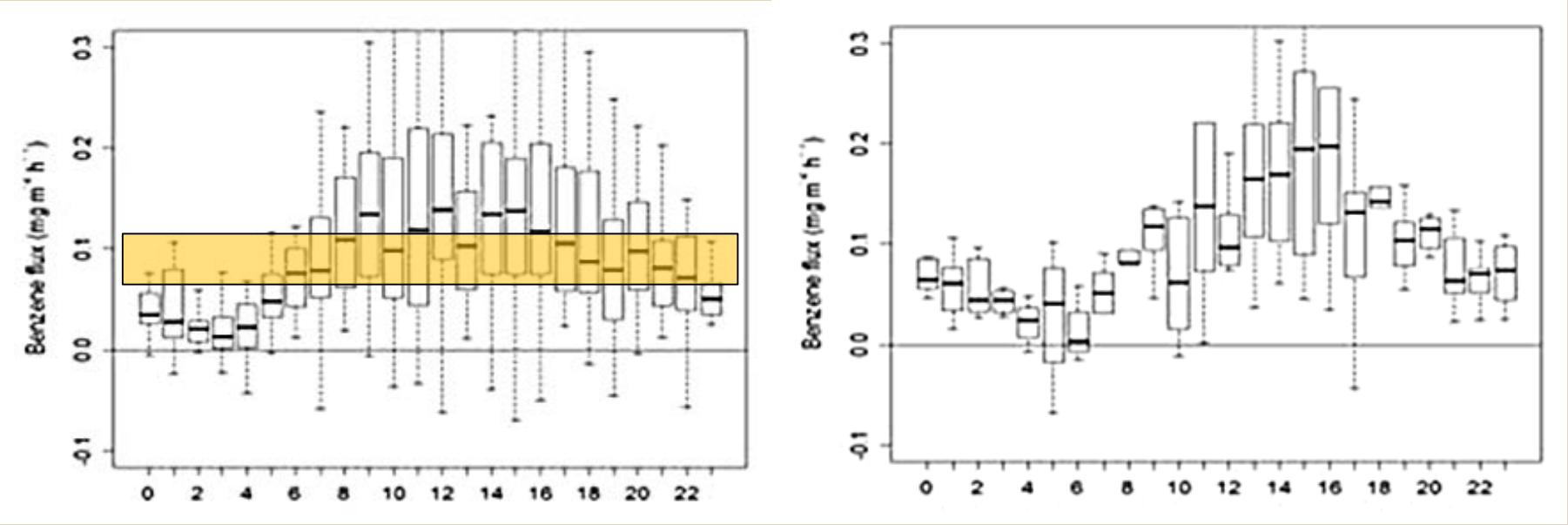
Schade et al., unpublished analysis

Criteria Pollutant Fluxes, IV



Schade et al., unpublished analysis

VOC fluxes, I



Benzene fluxes are low, not entirely driven by traffic

BTX fluxes dropping ~10-15% per year

Hu et al., JGR 2014: factor 2.0-4.5 EPA inventory overestimate (2011)

Benzene: Lu et al.: 206 Gg C, from above: 184 Gg C (!)

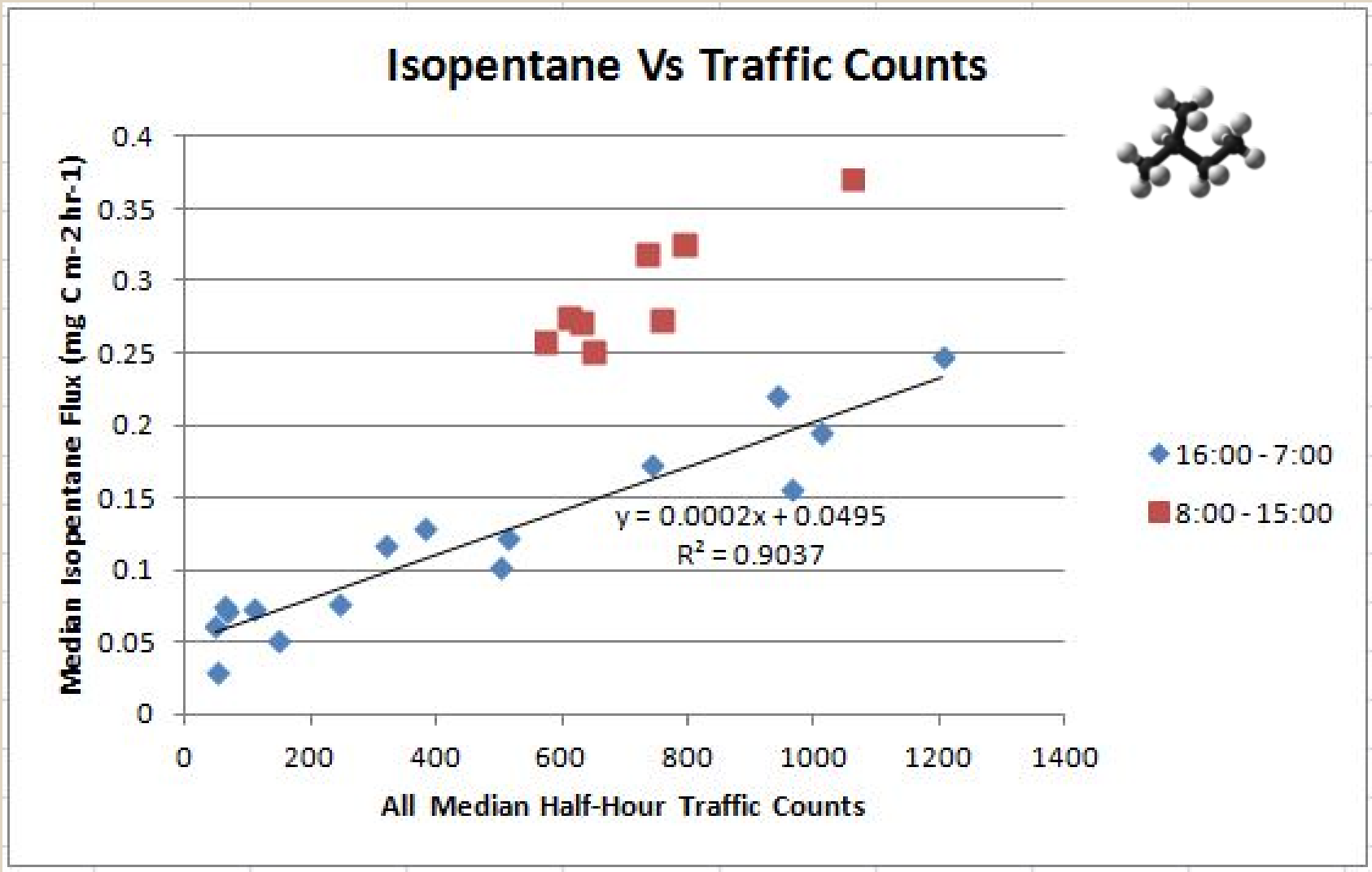
M. Hale, MSc thesis 2014

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%**	

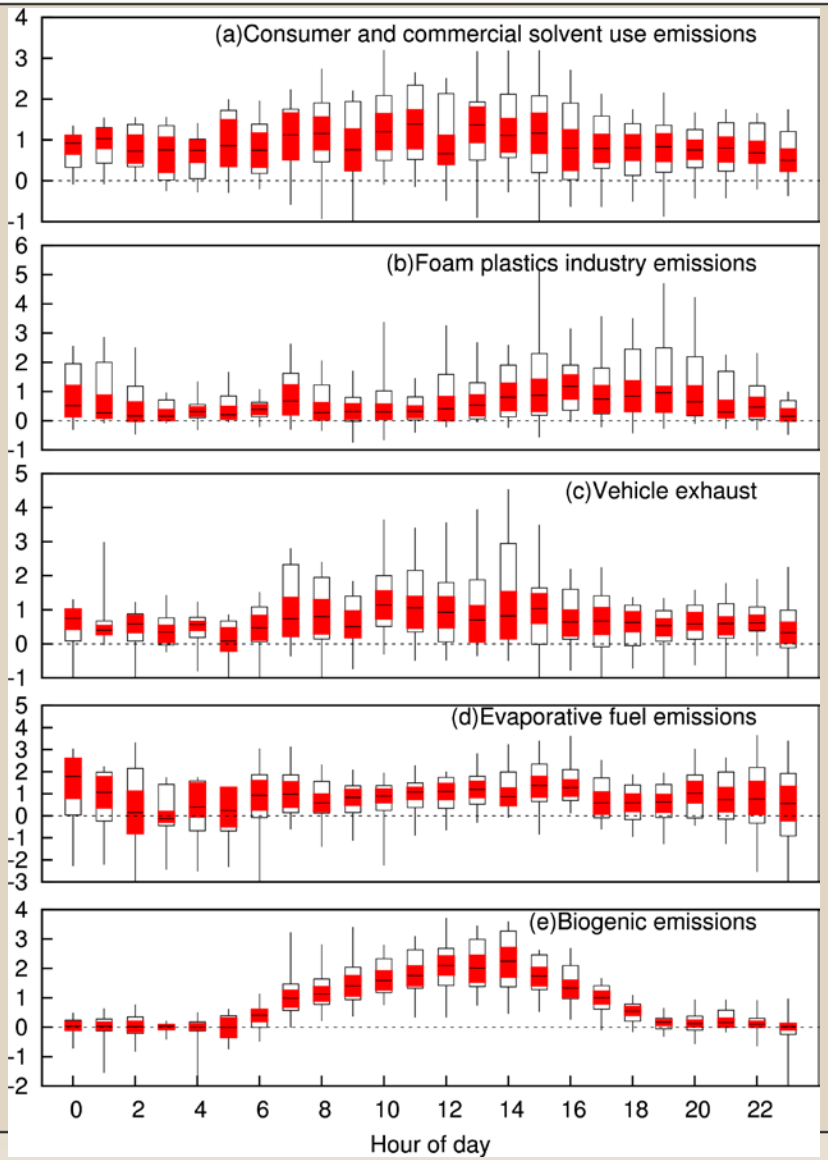
Data in mg m^{-2} h^{-1}, M. Hale, MSc thesis 2014

VOC fluxes, II



M. Hale, MSc thesis 2014

VOC fluxes, III

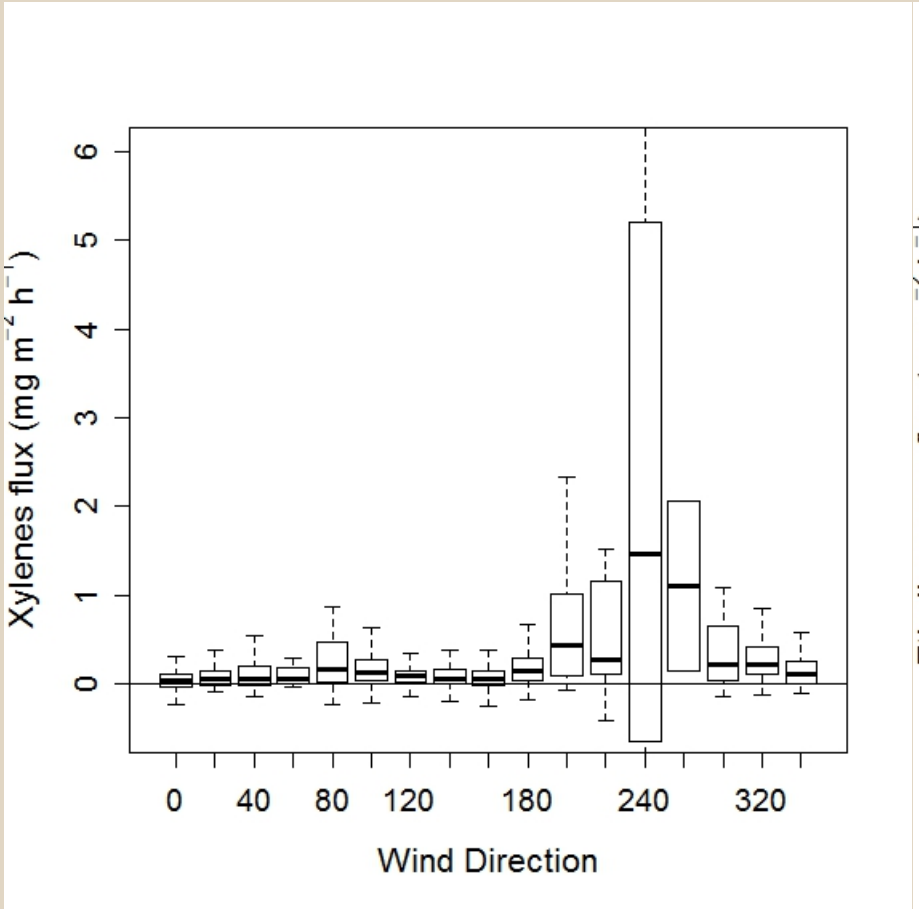


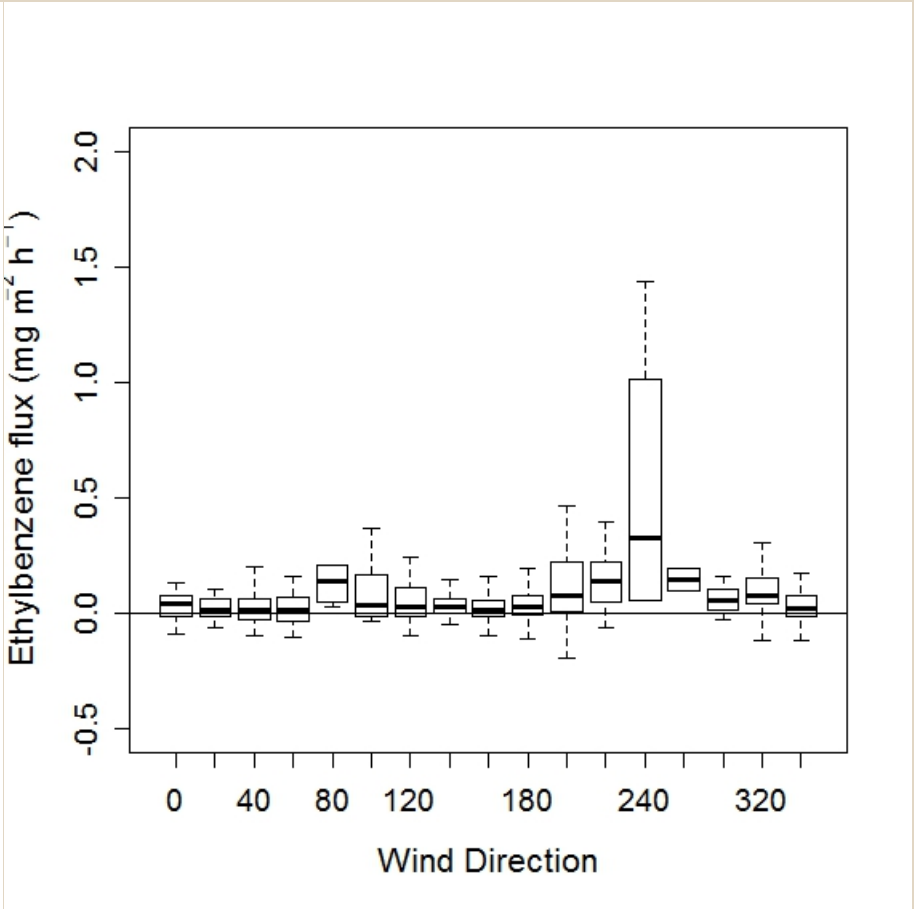
- makeup, paint, etc.
- industry
- your car exhaust
- your (car) fuel leak(s)
- local oak trees

Kota et al., Atmos. Environ., 2014

VOC fluxes, IV

Xylan© coating process facility, 200 m SSW of tower



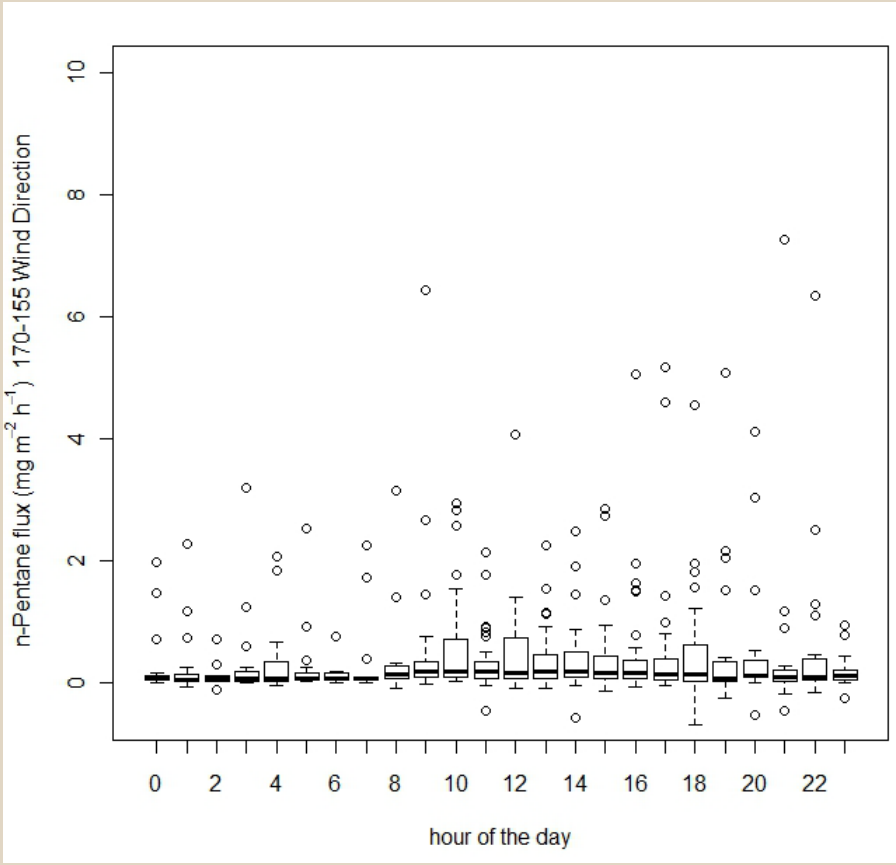


M. Hale, MSc thesis 2014

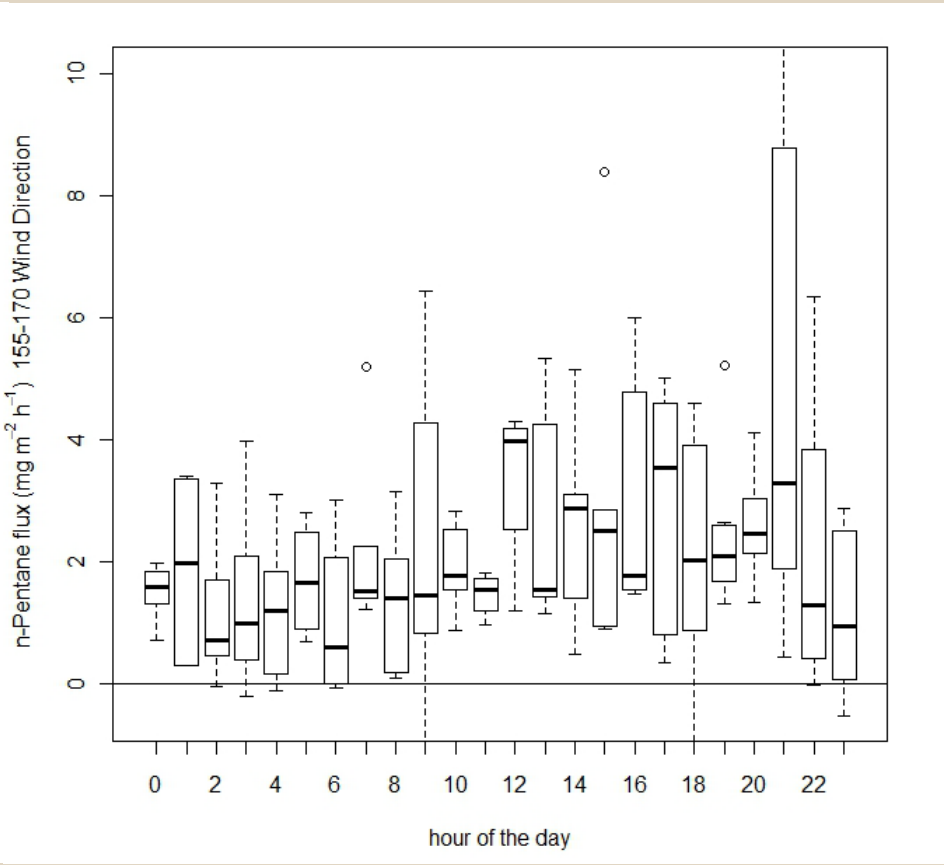
A Large Pentane Source, I

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

wind not from source



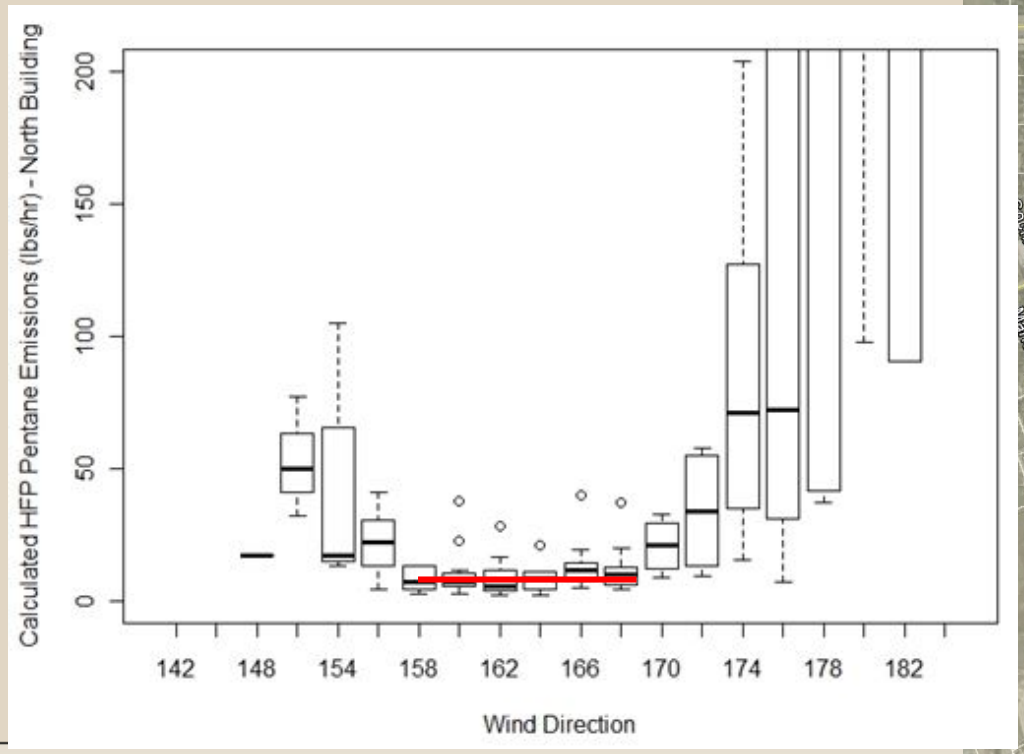
wind from pentane source

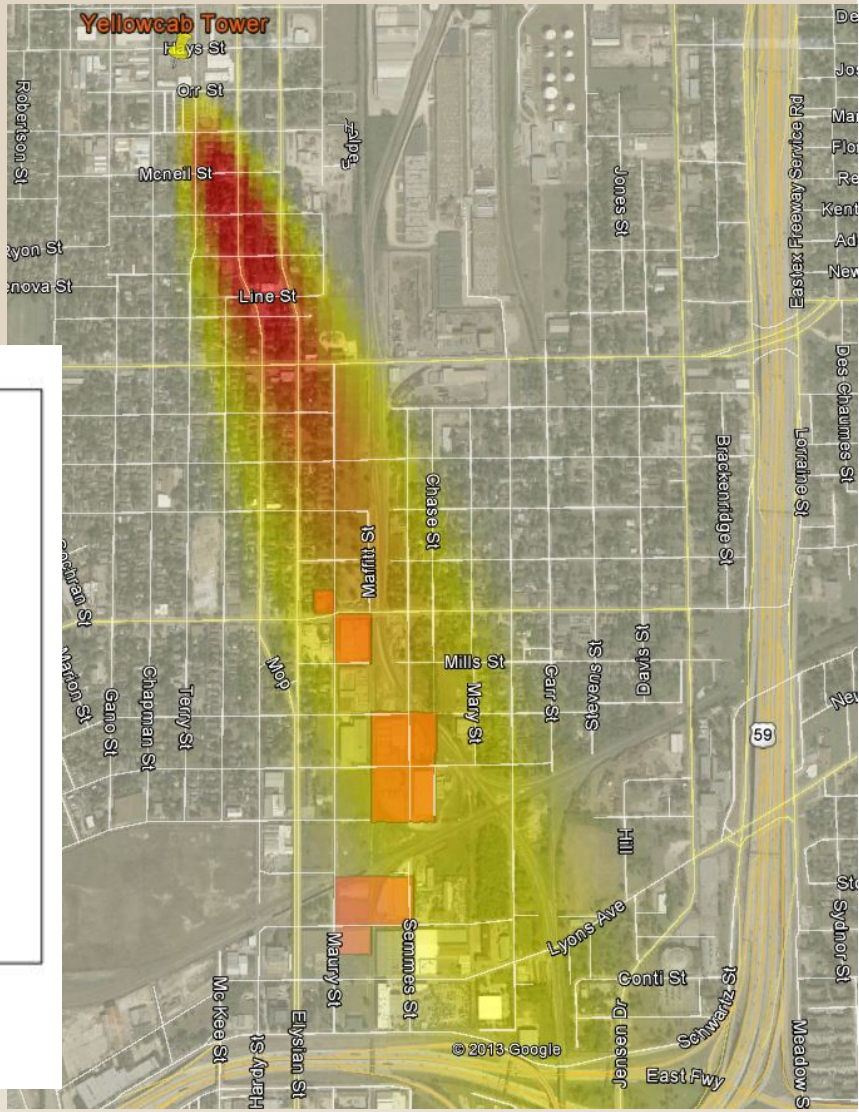


M. Hale, MSc thesis 2014

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

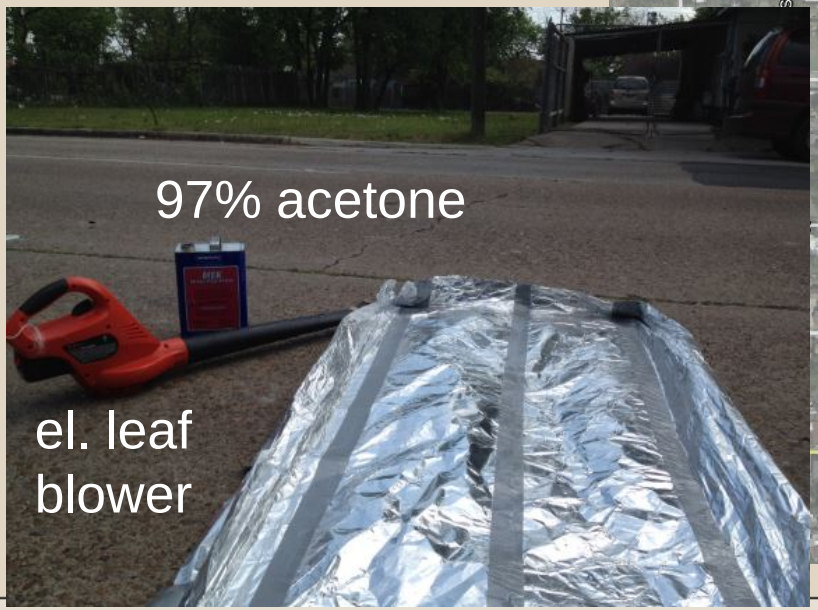




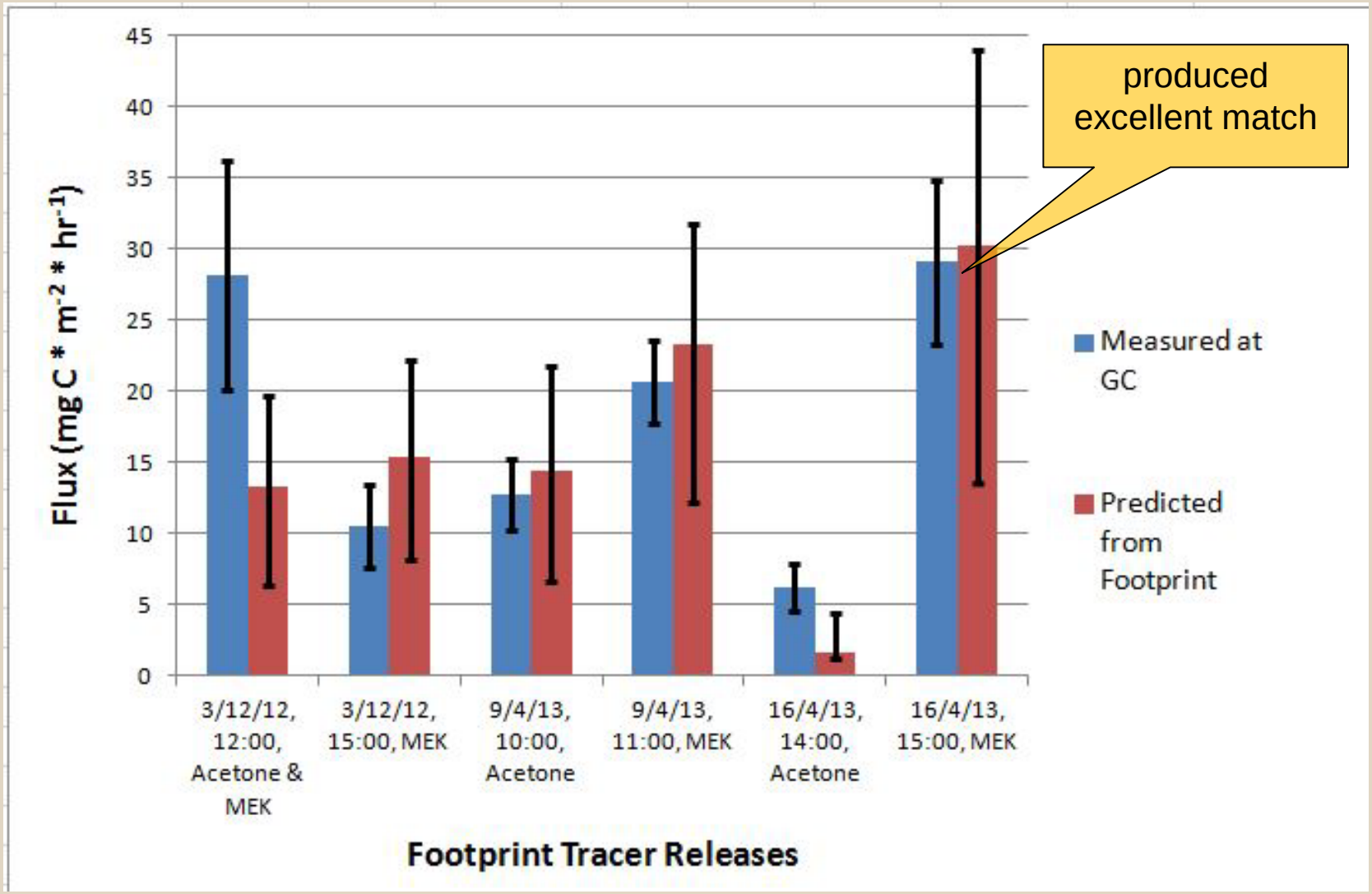
M. Hale, MSc thesis 2014

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



M. Hale, MSc thesis 2014

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
- unique seasonal VOC flux data
  - clear BTX 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