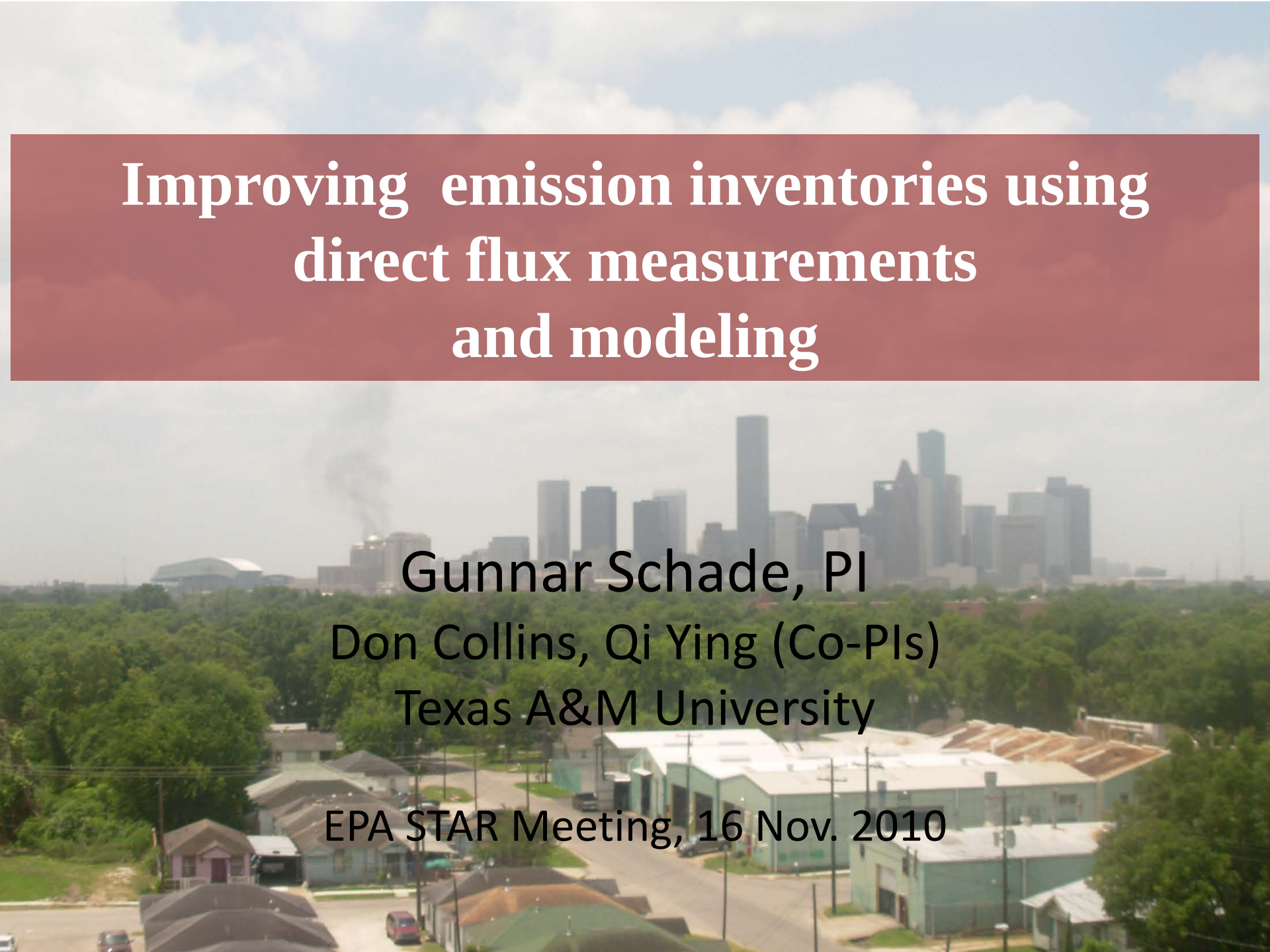
Improving emission inventories using direct flux measurements and modeling



Gunnar Schade, PI
Don Collins, Qi Ying (Co-PIs)
Texas A&M University

EPA STAR Meeting, 16 Nov. 2010

Overview

- Brief Introduction
- The Yellow Cab tower
  - challenges of an *urban* flux site
- Selected results from previous measurements
  - Energy exchange fluxes
  - CO_2 and criteria pollutants
  - VOCs
- EPA STAR fund activities and measurements

Introduction, I

- Regional Air Quality (AQ) modeling improved
  - uses submodels for
    - emissions distribution ("inventory")
    - atmospheric transport and chemistry
  - Emissions Inventory (EI) often assumed as being known well
- Ambient AQ measurements challenge some EI assumptions; inadequate?
  - **<u>Can the EI be improved?</u>**

Introduction, II

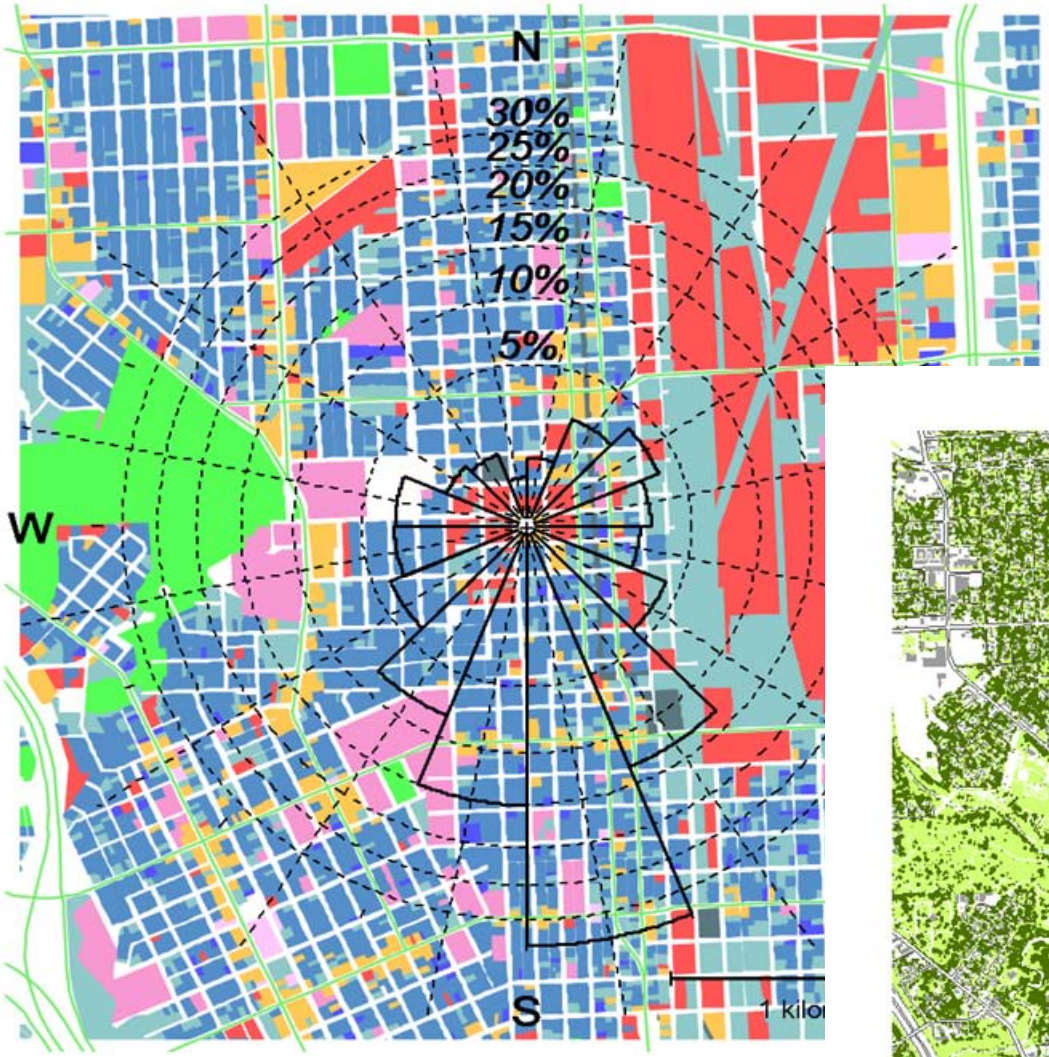
- Past efforts of EI improvement
  - multivariate source apportionment using ambient AQ (concentration) data
  - 'real-world' emission measurements (tunnel studies)
  - AQ model studies

- **Our approach**
  - micrometeorological flux measurements
    - top-down – bottom-up comparison
      - EI model AND AQ model testing

Site Description, I

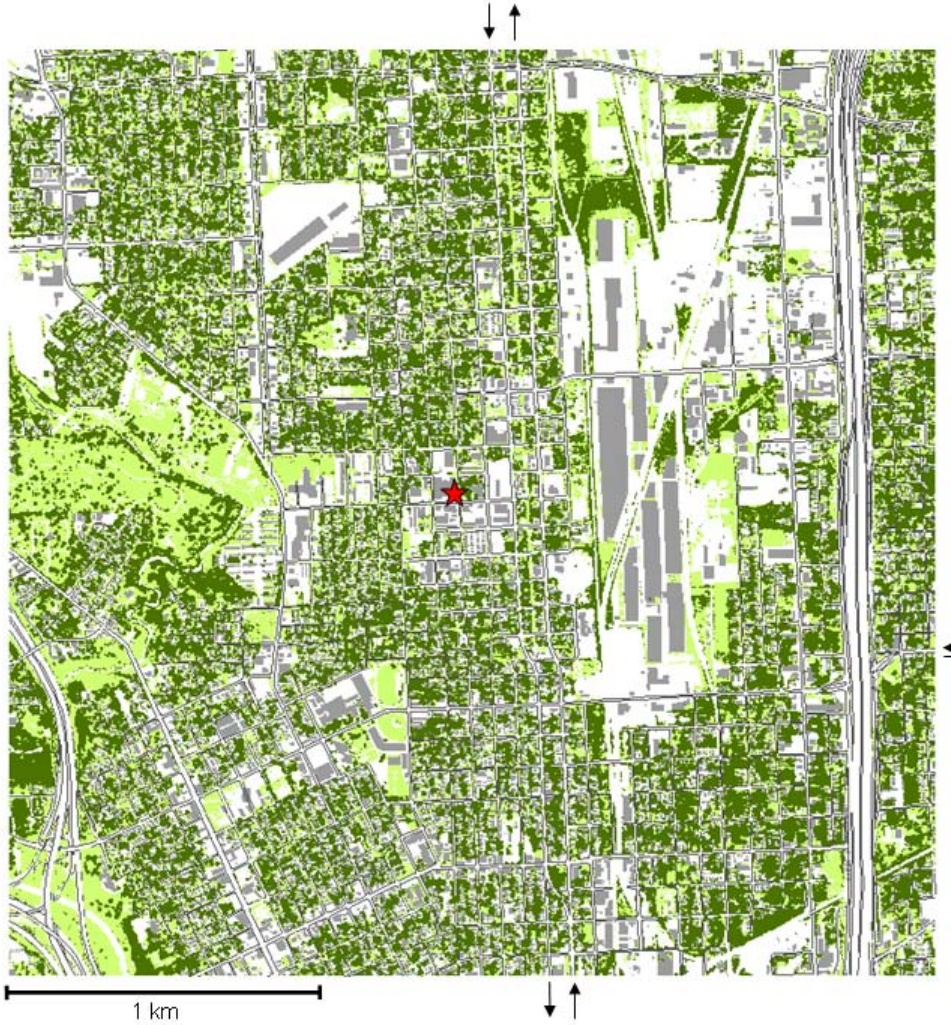
Site Description, II

land use



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

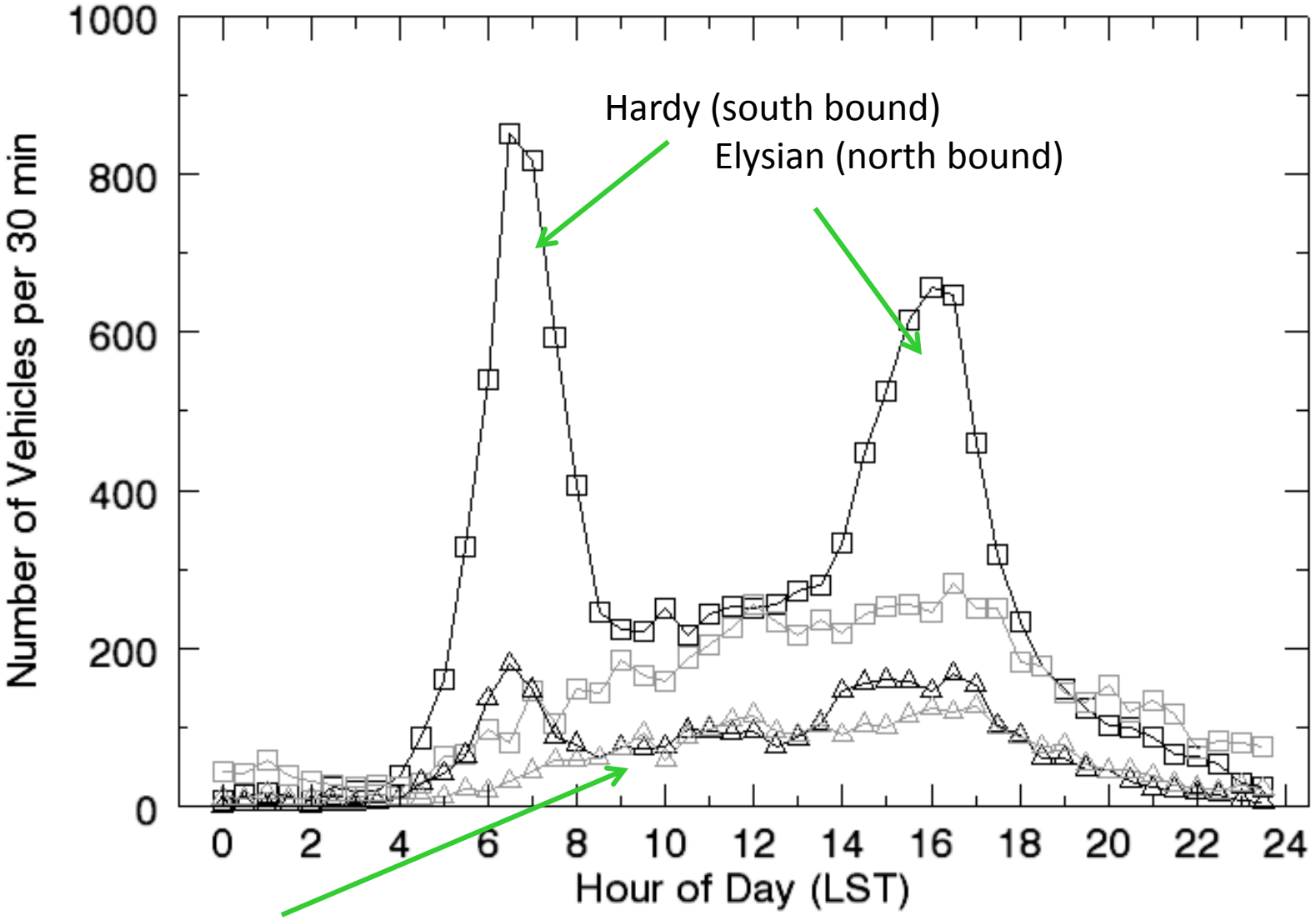
land cover



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

Hardy / Elysian Roads

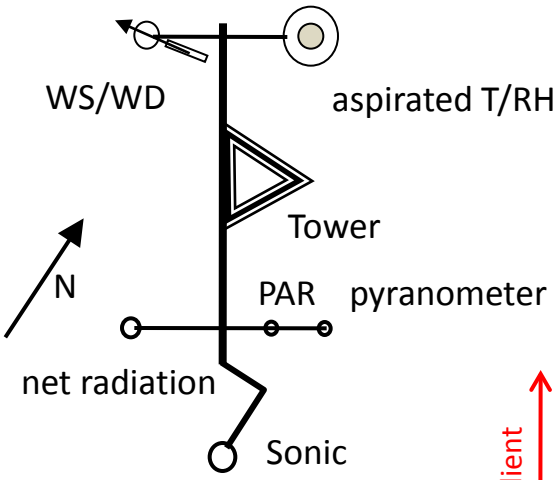
Traffic Counts

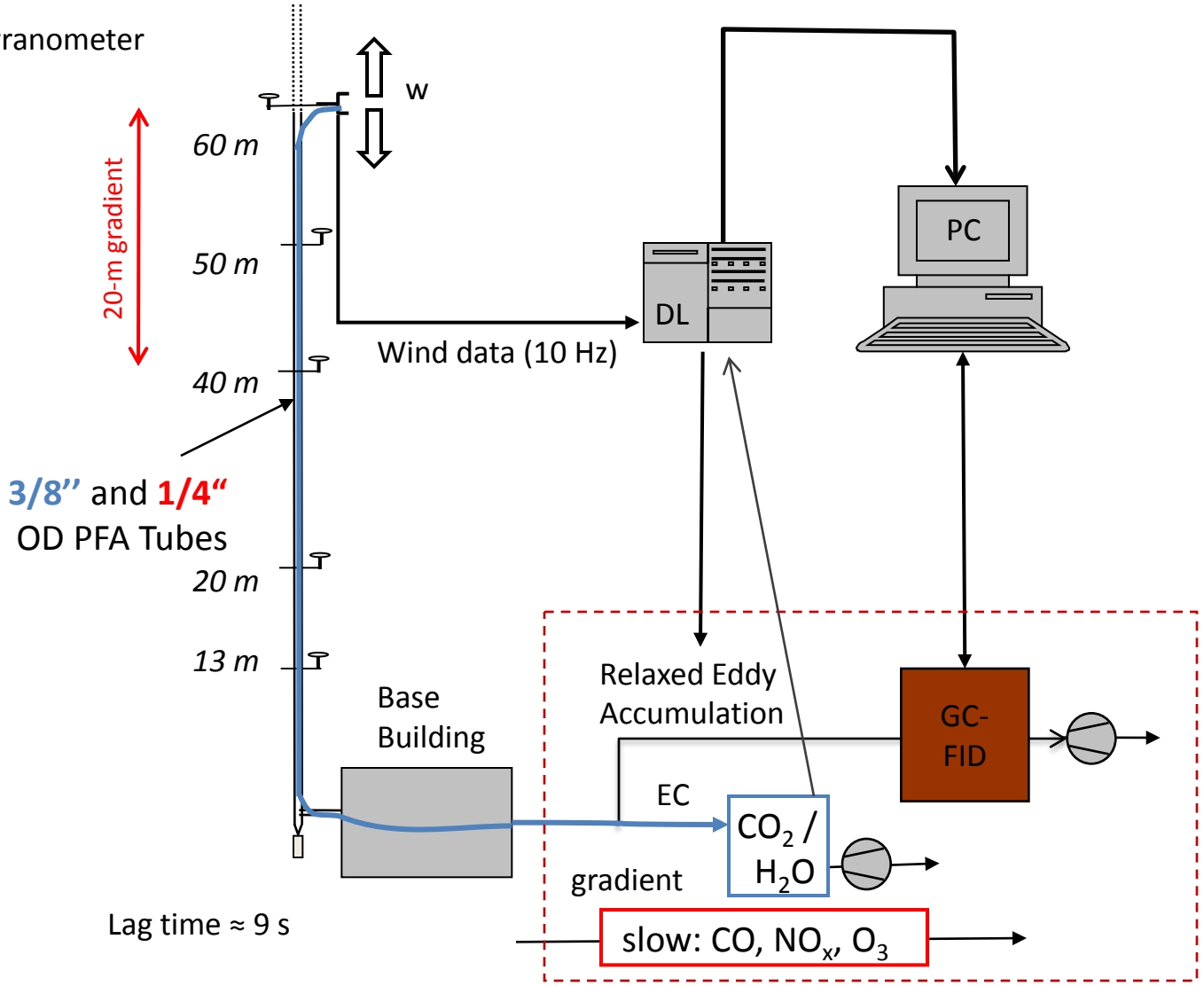


Quitman Road (east/west bound)


CHAPMAN 2500

Tower Measurement Setup





Tower installations

The challenge

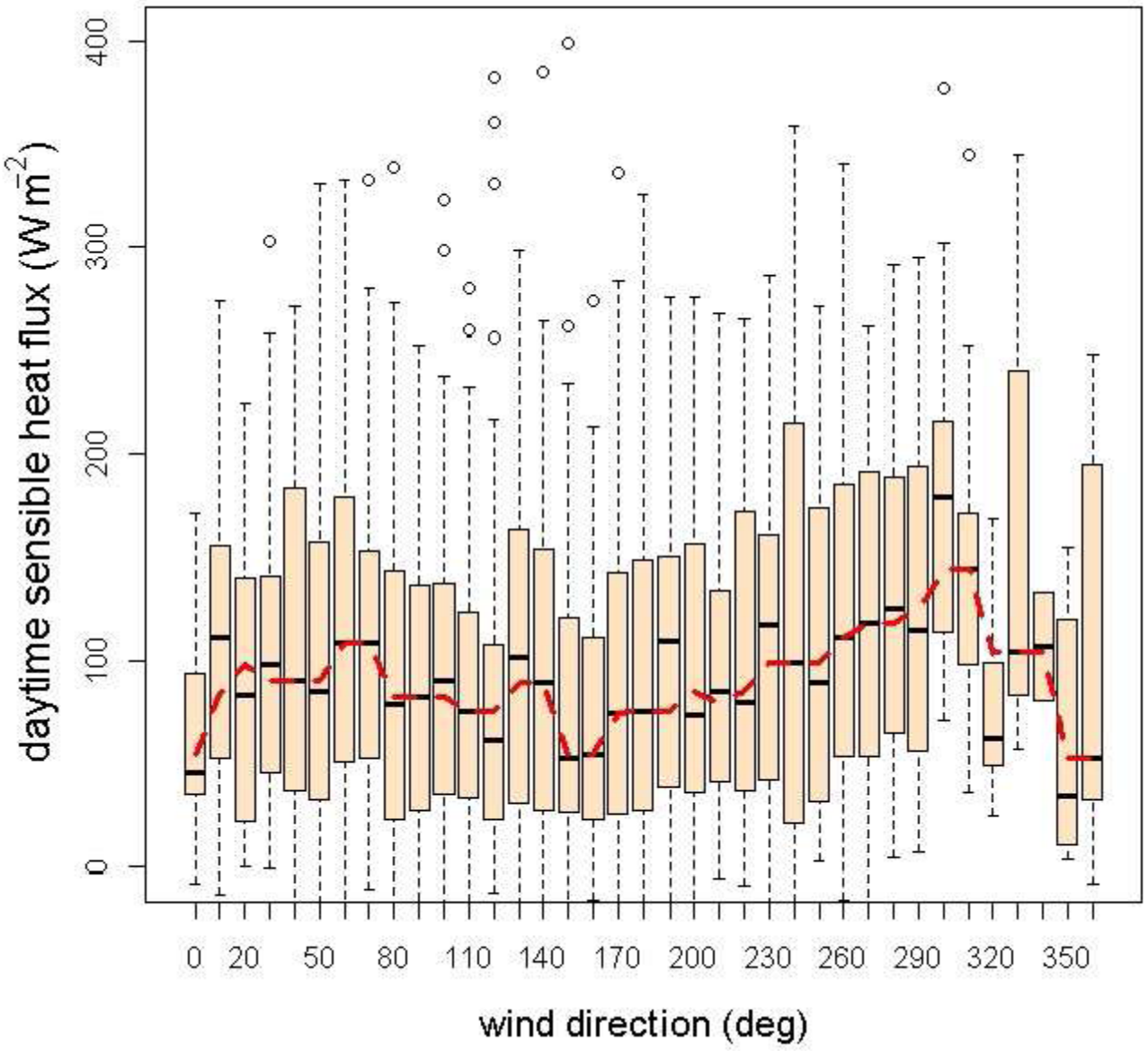
'Ordinary' flux site

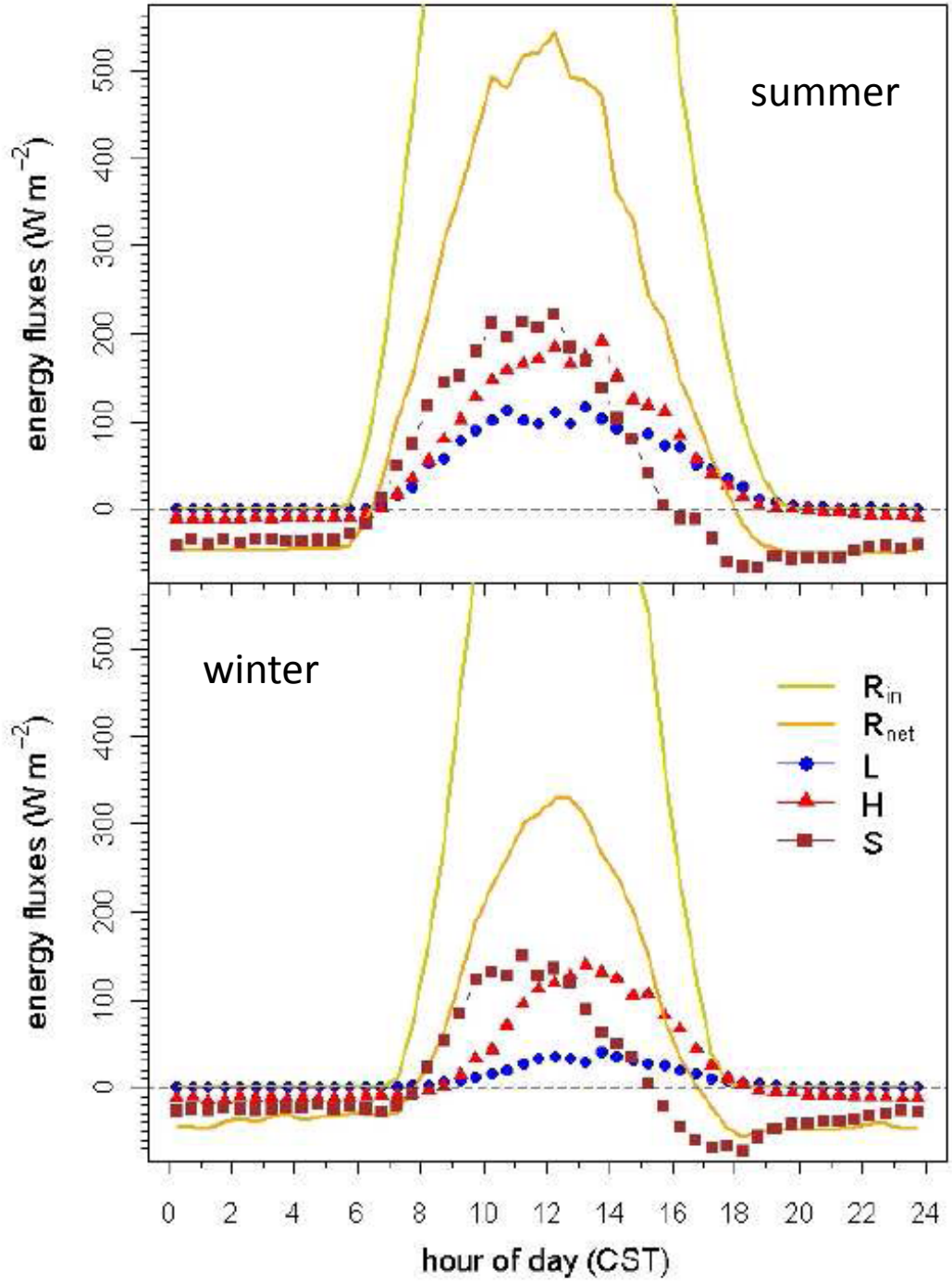
- homogeneous land cover
  - well-defined footprint (MO theory)
  - well-defined flux contributors
  - limited variability
- process studies
  - attention to detail
- access to surface sites
  - upscaling / downscaling

Urban flux site

- heterogeneous land cover
  - ill-defined footprint
    - roughness sublayer
  - ill-defined flux contributors
  - high variability
- 'chaos' studies
  - attention to averages/medians
- limited access
  - private property
  - undocumented activities

Energy exchange fluxes, I

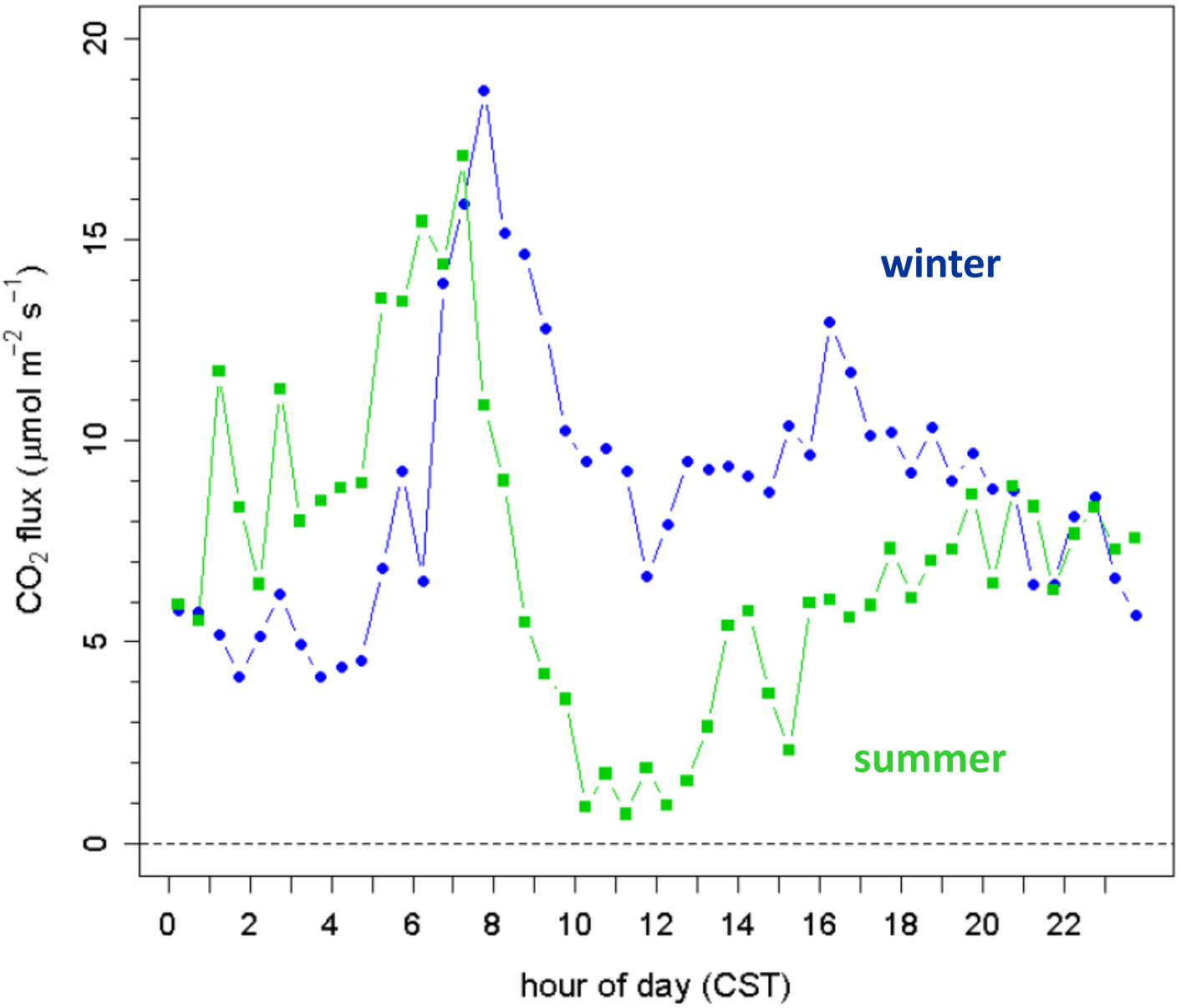




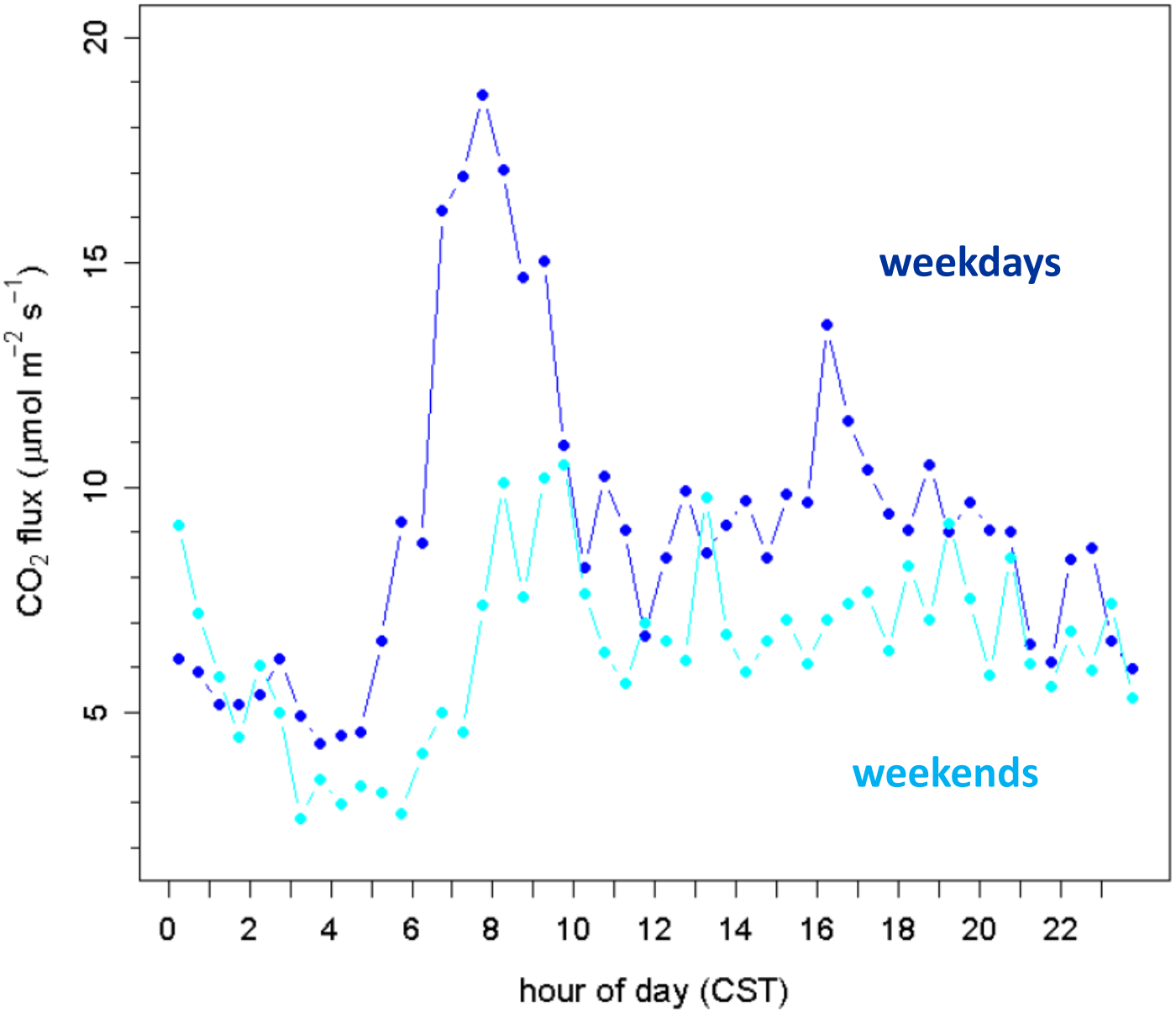
Energy exchange fluxes, II

- delayed sensible heat flux
- significant latent cooling
- large heat storage and release (with hysteresis)

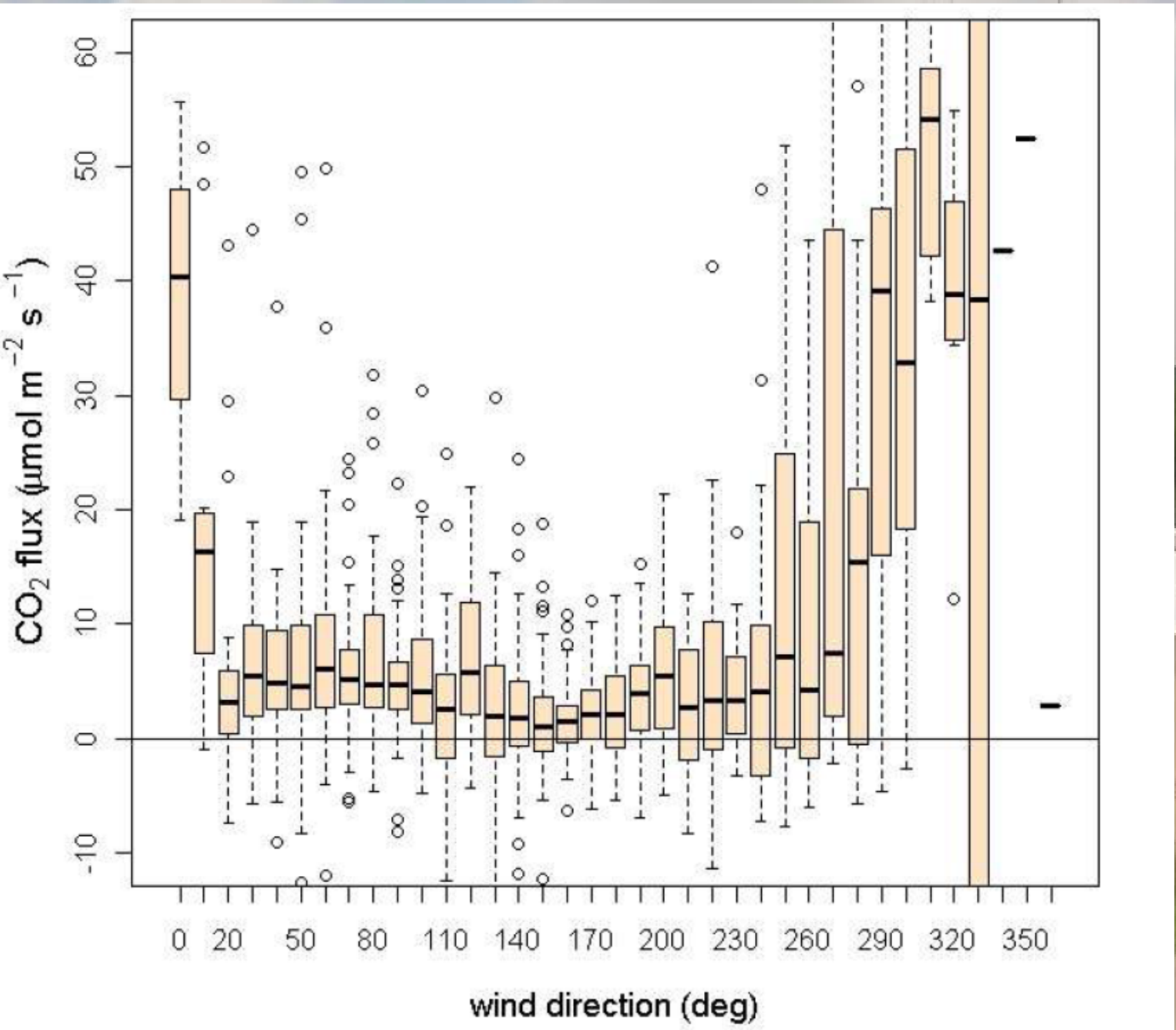
Carbon dioxide (CO_2) fluxes, I



Carbon dioxide (CO_2) fluxes, II

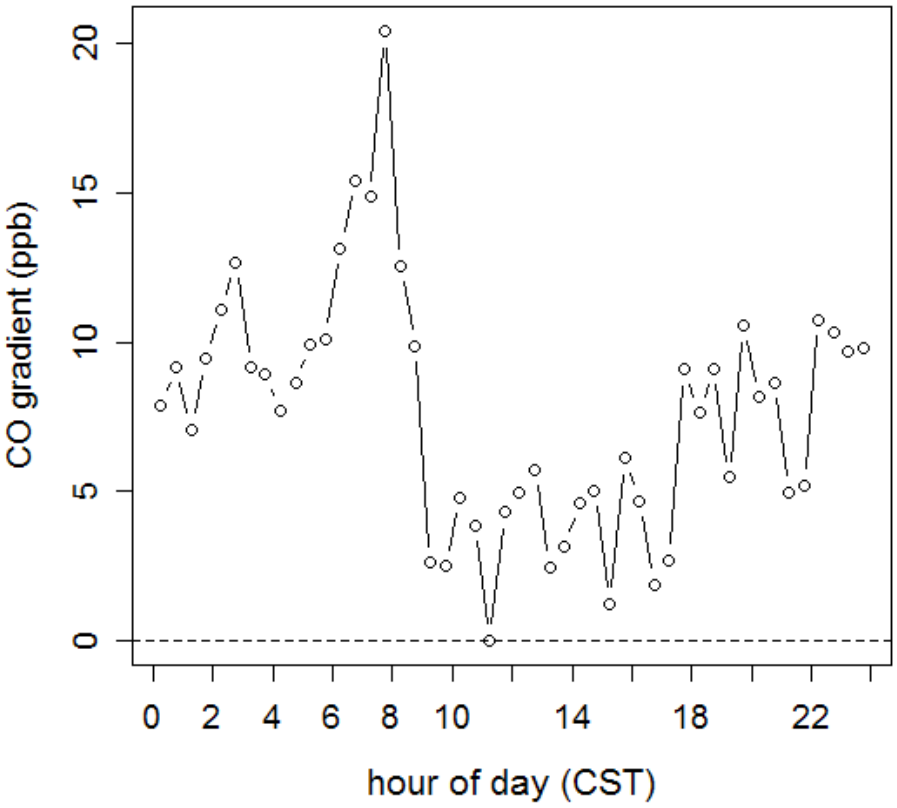


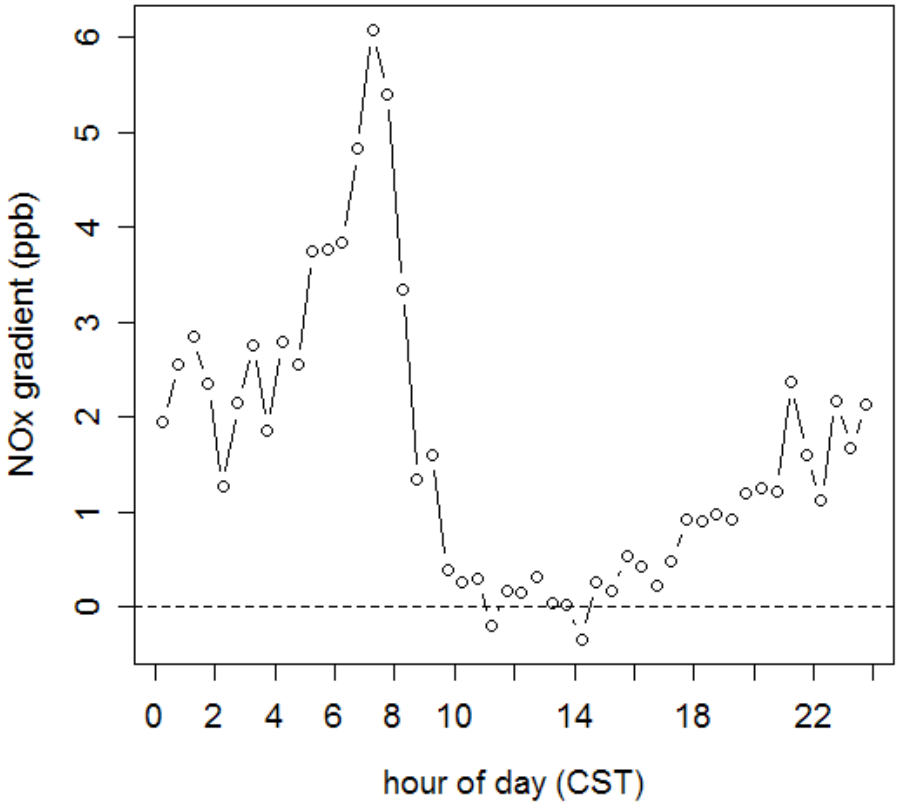
Carbon dioxide (CO_2) fluxes, III



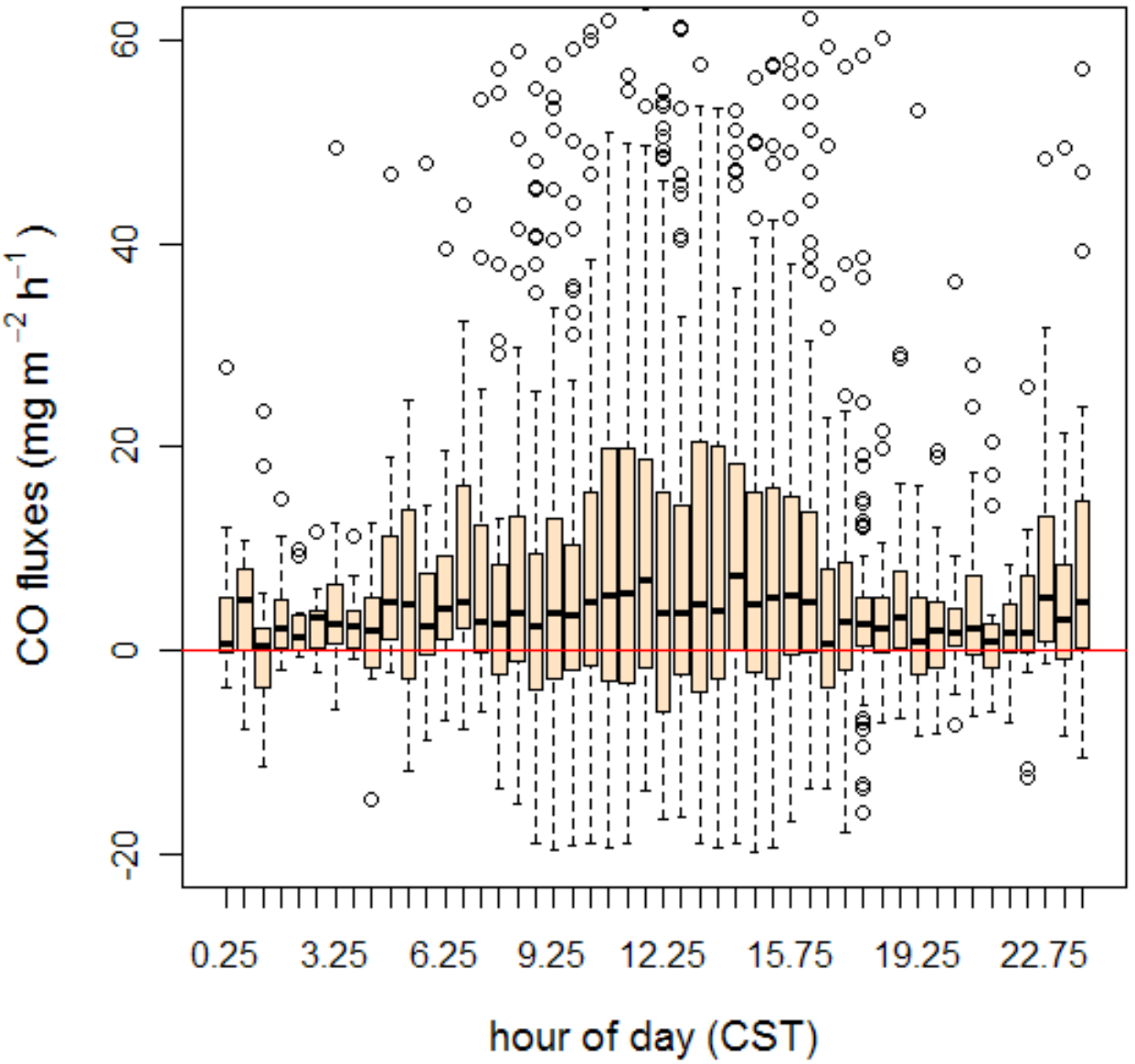
Criteria Pollutant Fluxes, I

Summertime (multi-month) medians

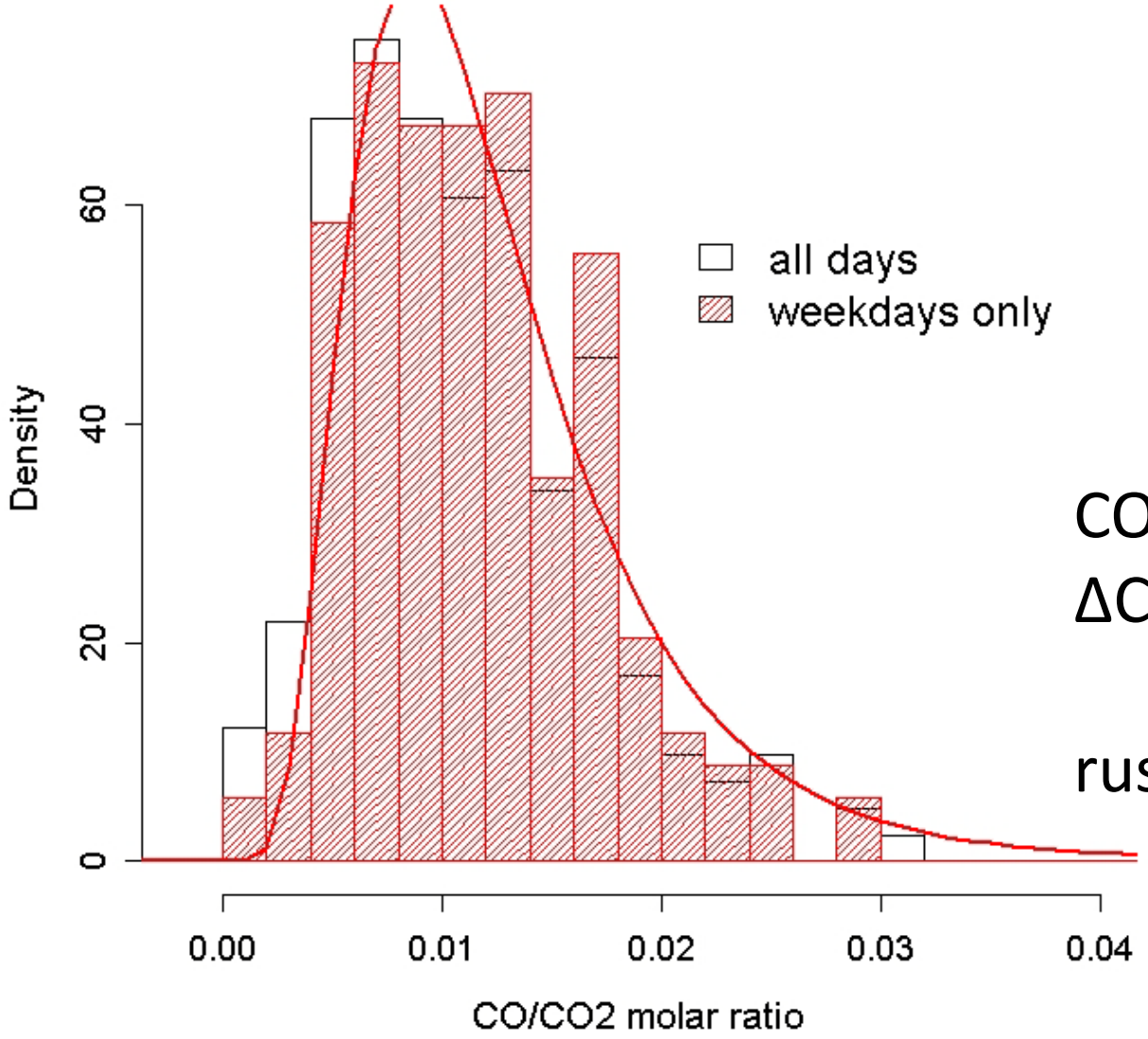




Criteria Pollutant Fluxes, II



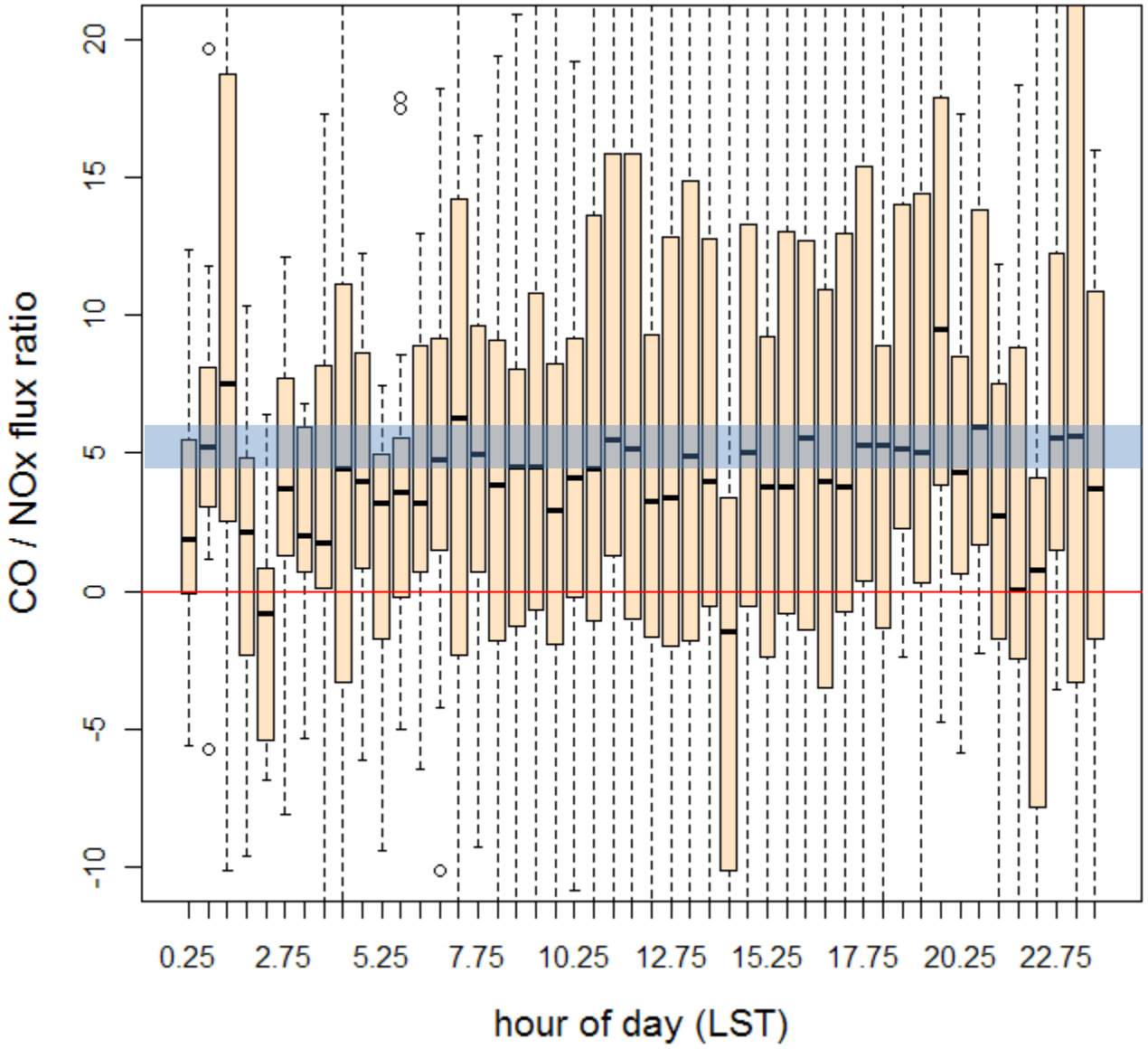
Criteria Pollutant Fluxes, III



CO-Flux ≈
$\Delta CO / \Delta CO_2 \times F_{CO2}$

rush-hour only

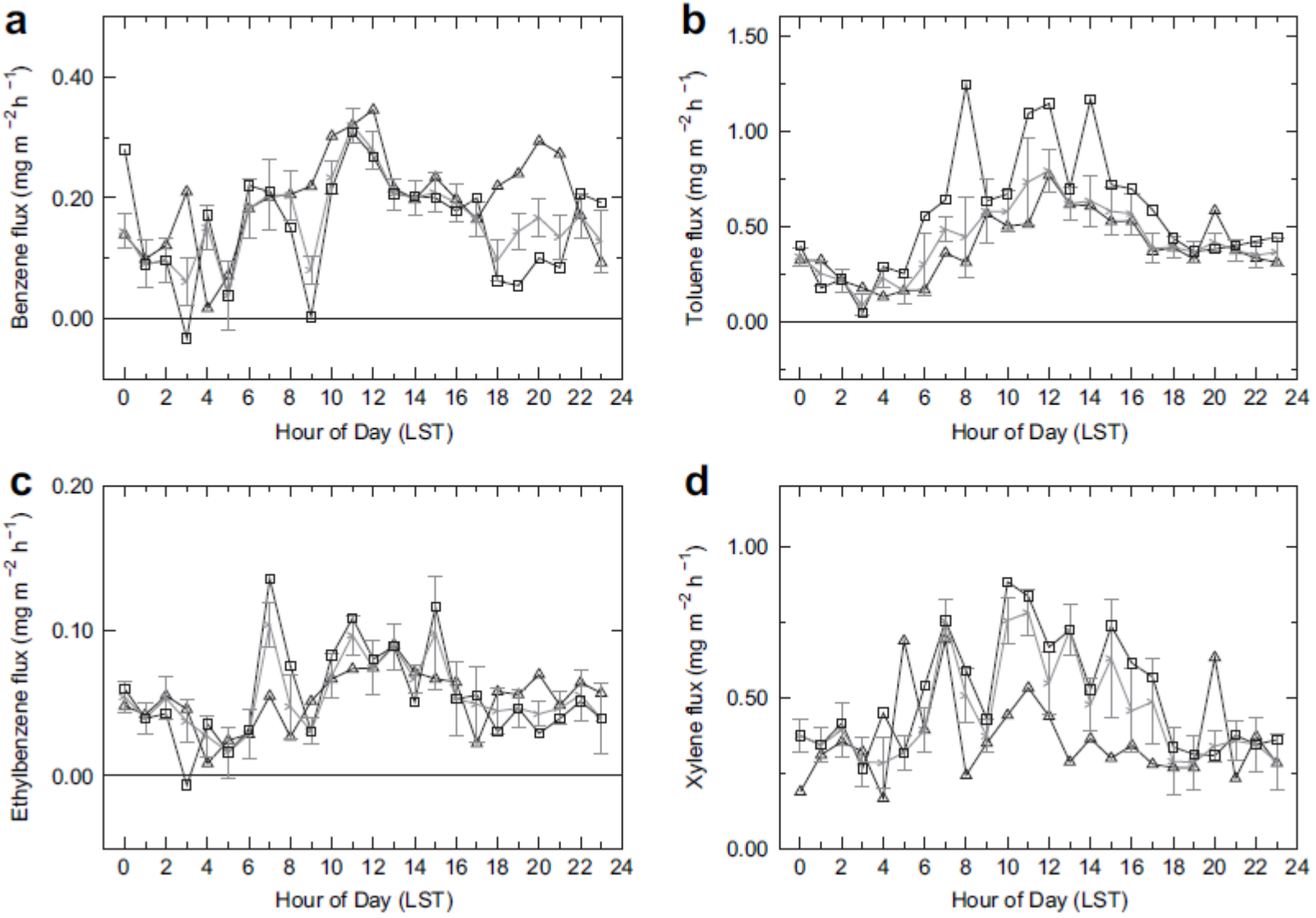
Criteria Pollutant Fluxes, IV



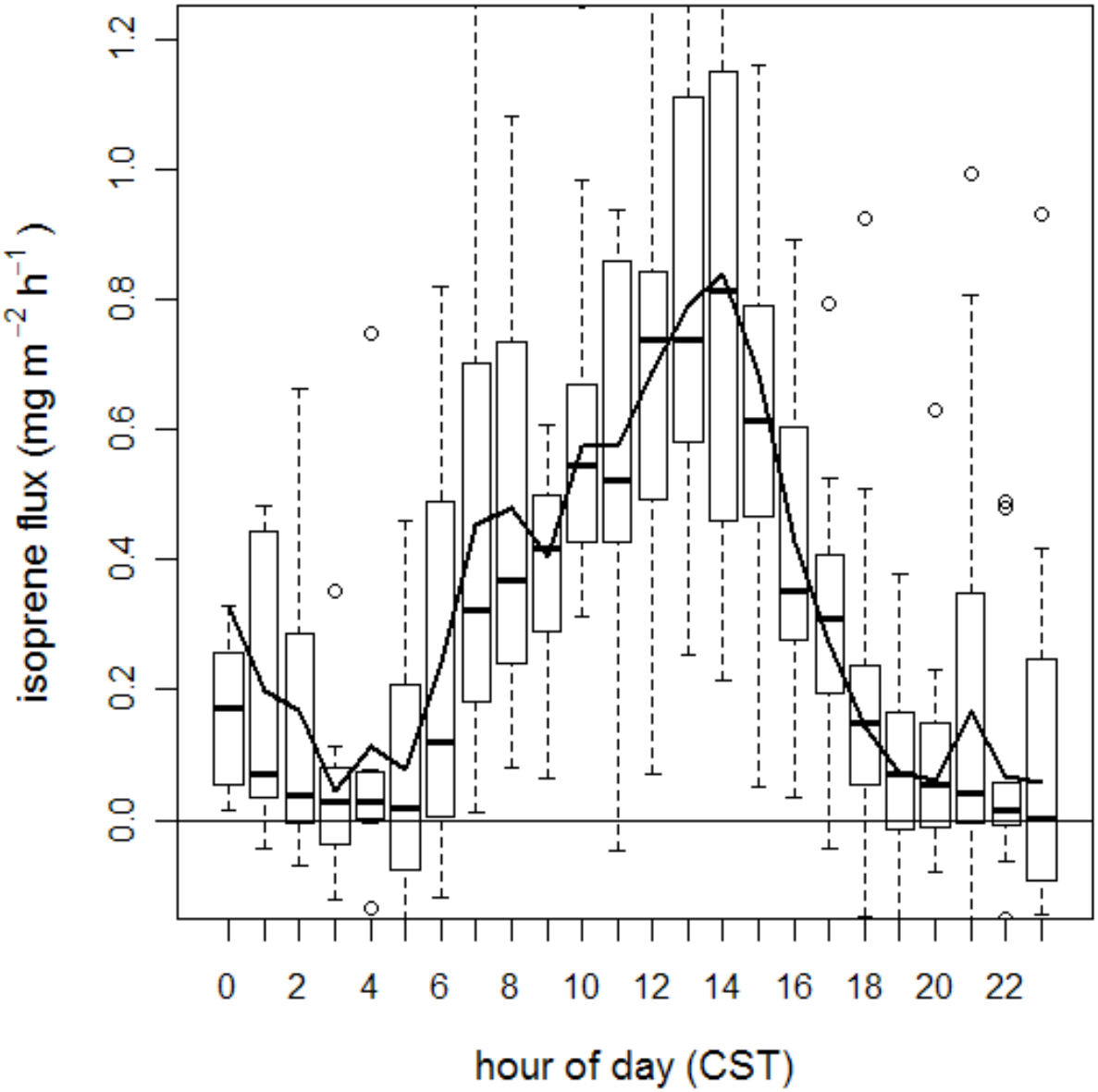
TexAQS 2006

VOC fluxes, I

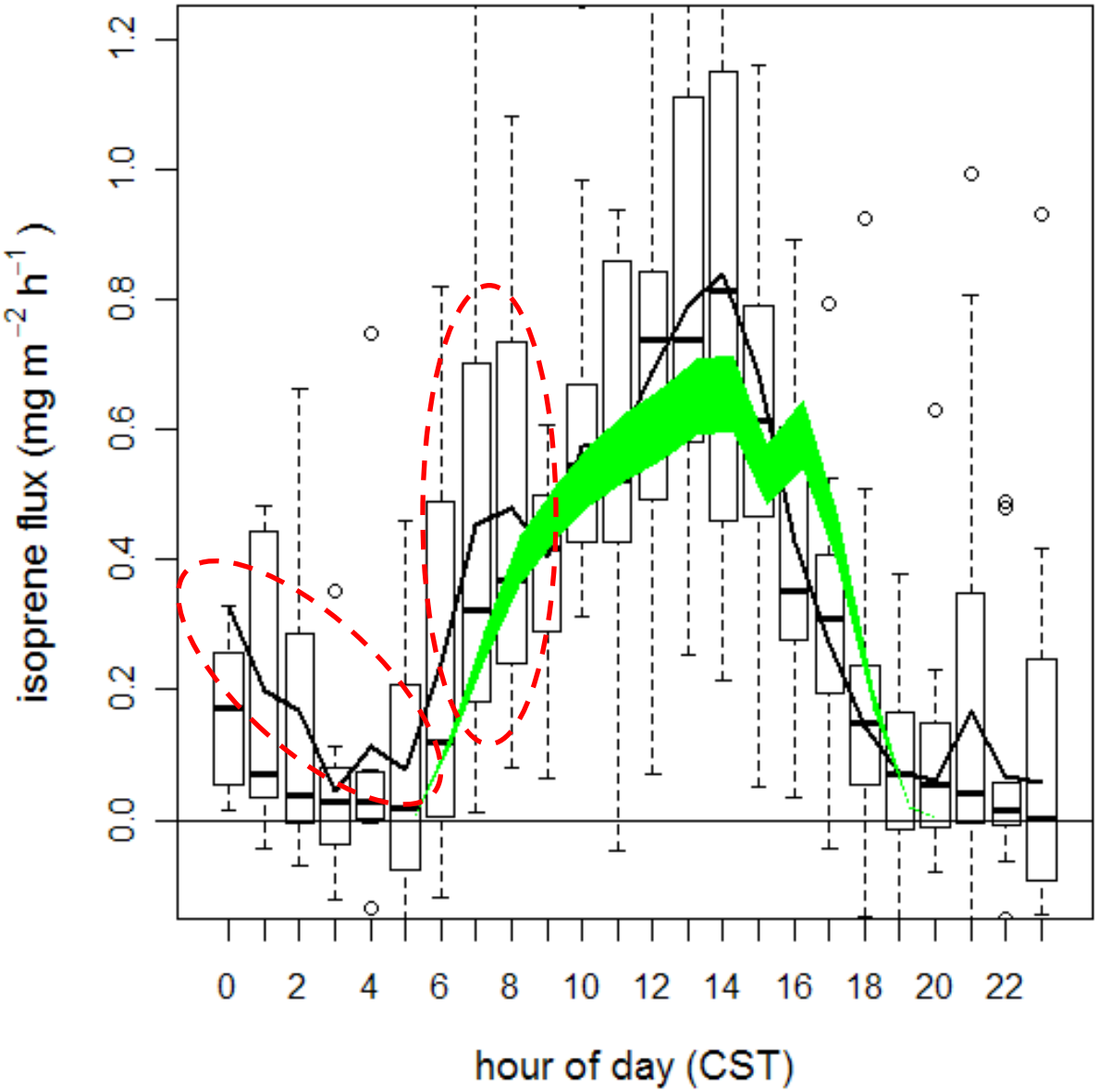
C. Park et al. / Atmospheric Environment 44 (2010) 2605–2614



VOC fluxes, II



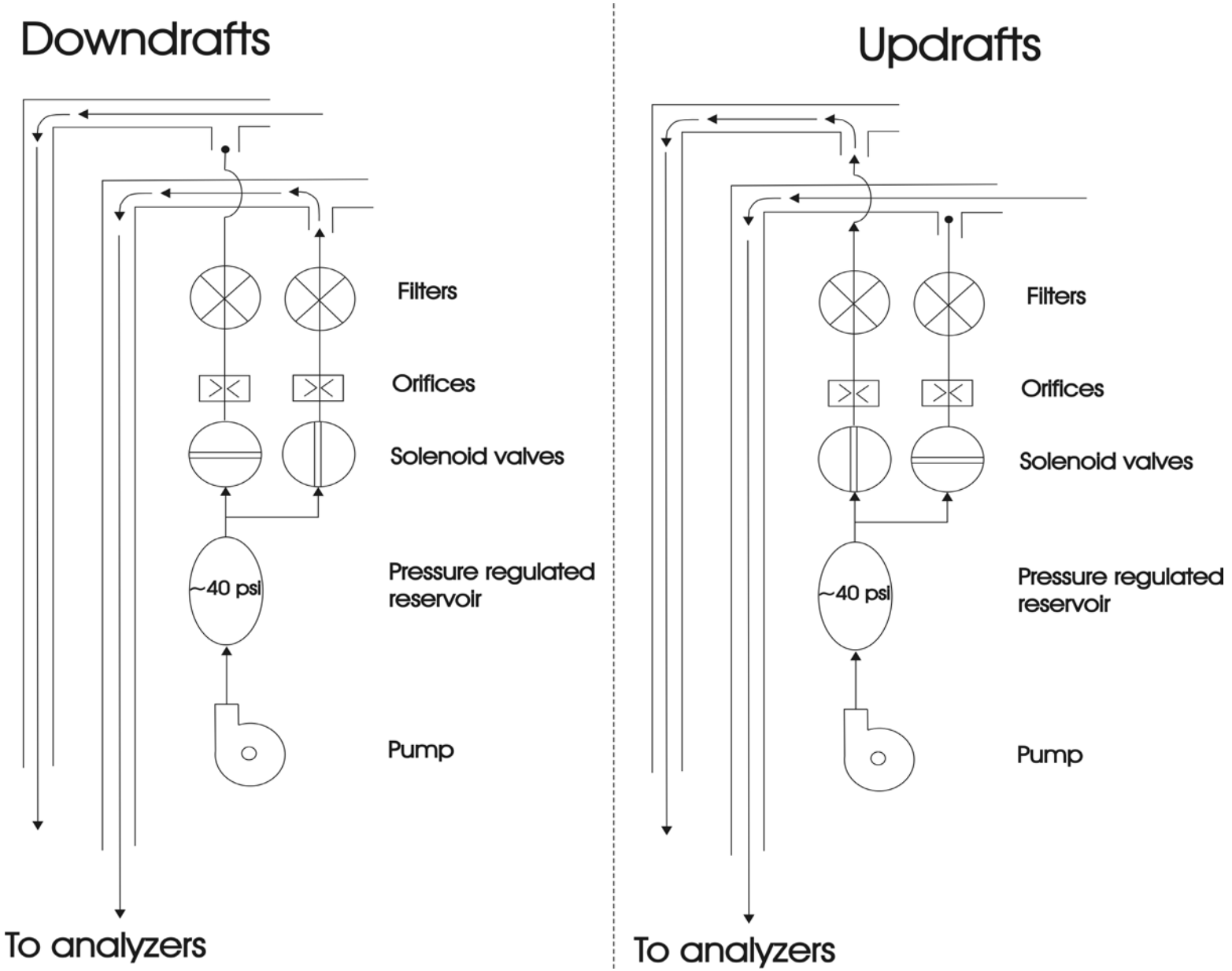
VOC fluxes, II



STAR grant activities

- continued (improved) measurements (G. Schade)
  - criteria pollutants (ongoing) and VOCs (2011+2012)
  - gradient (CP, ongoing) and REA flux (VOCs, 2011+2012)
  - potentially EC CO fluxes (loaned instrument; 2011)
- additional aerosol (flux) measurements (D. Collins)
  - particle number fluxes (2011+2012)
- modeling (G. Schade, Qi Ying)(ongoing)
- (more detailed) ground survey
  - GIS improvements (ongoing)
  - roadside measurements (2011)
  - 'undocumented' emissions (2011)

Aerosol flux measurements, I

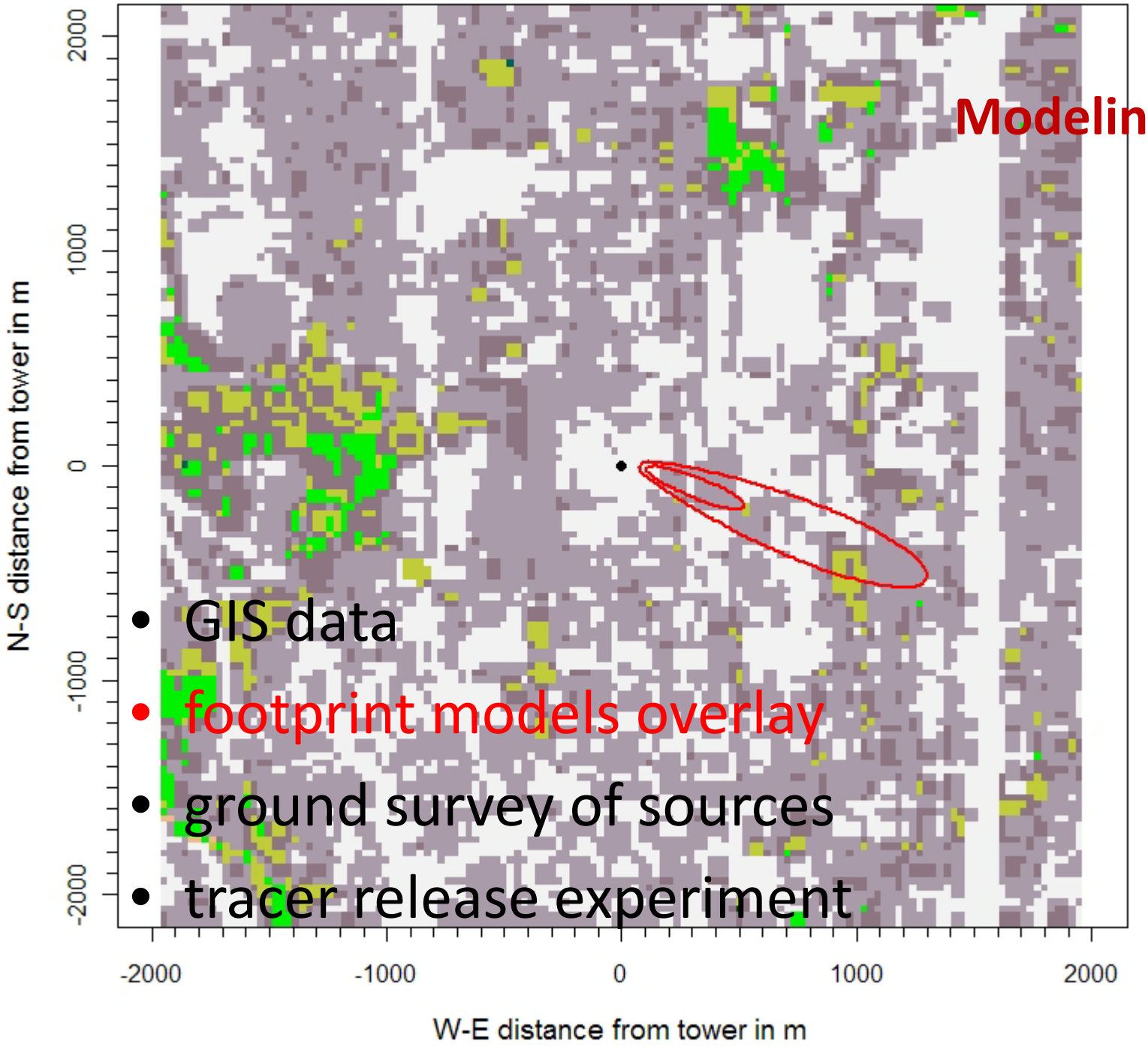


Aerosol flux measurements, II

- approx. 80 m SS tubing, laminar flow
  - insulated
  - size-dependent line loss tests
- one or two instruments
  - Initial measurement with DMA
    - accumulate density measurements over 30 min
  - APS installed and to be used if losses not excessive

➢ particle flux per size range per half hour

Modeling, I

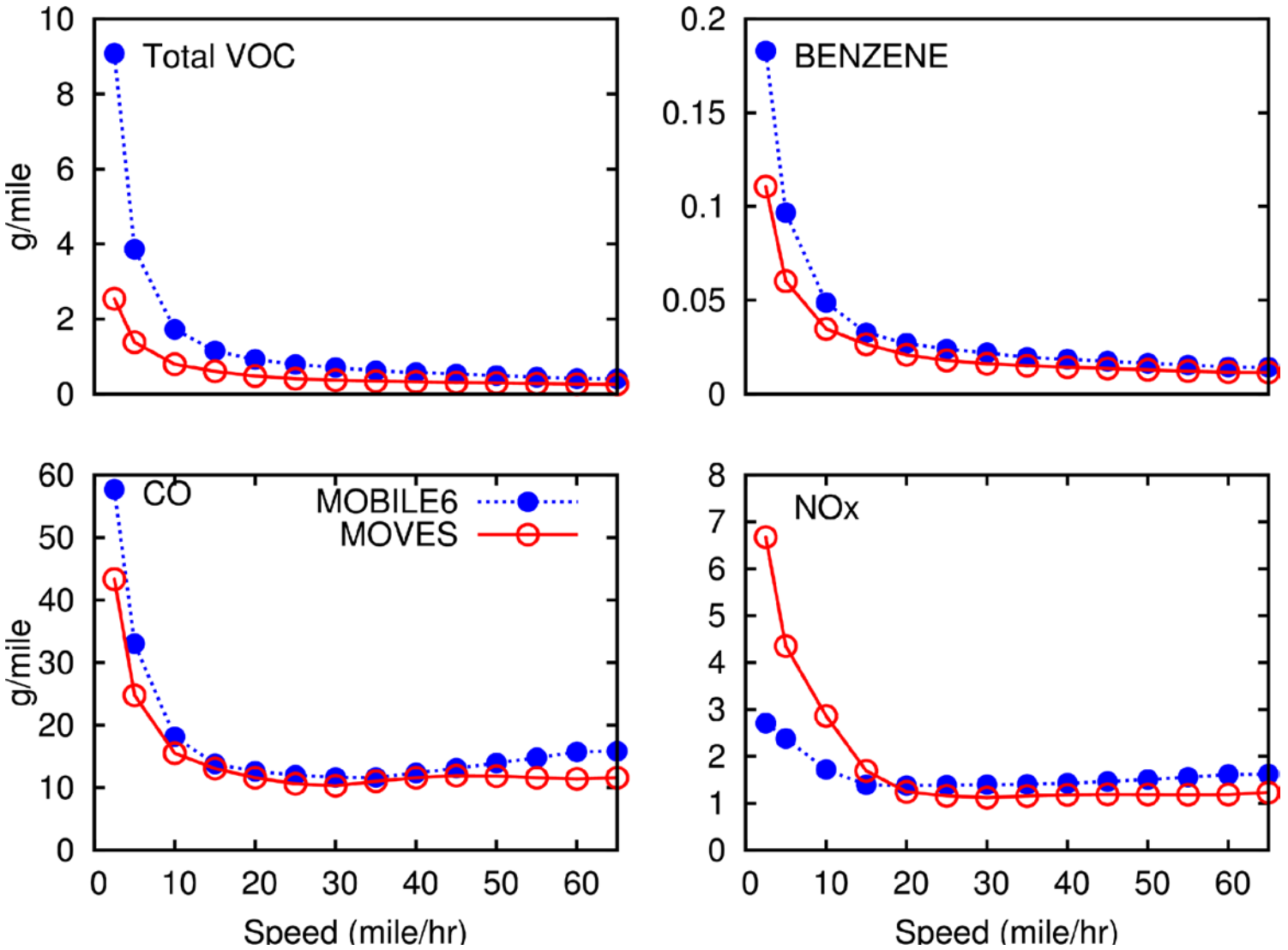


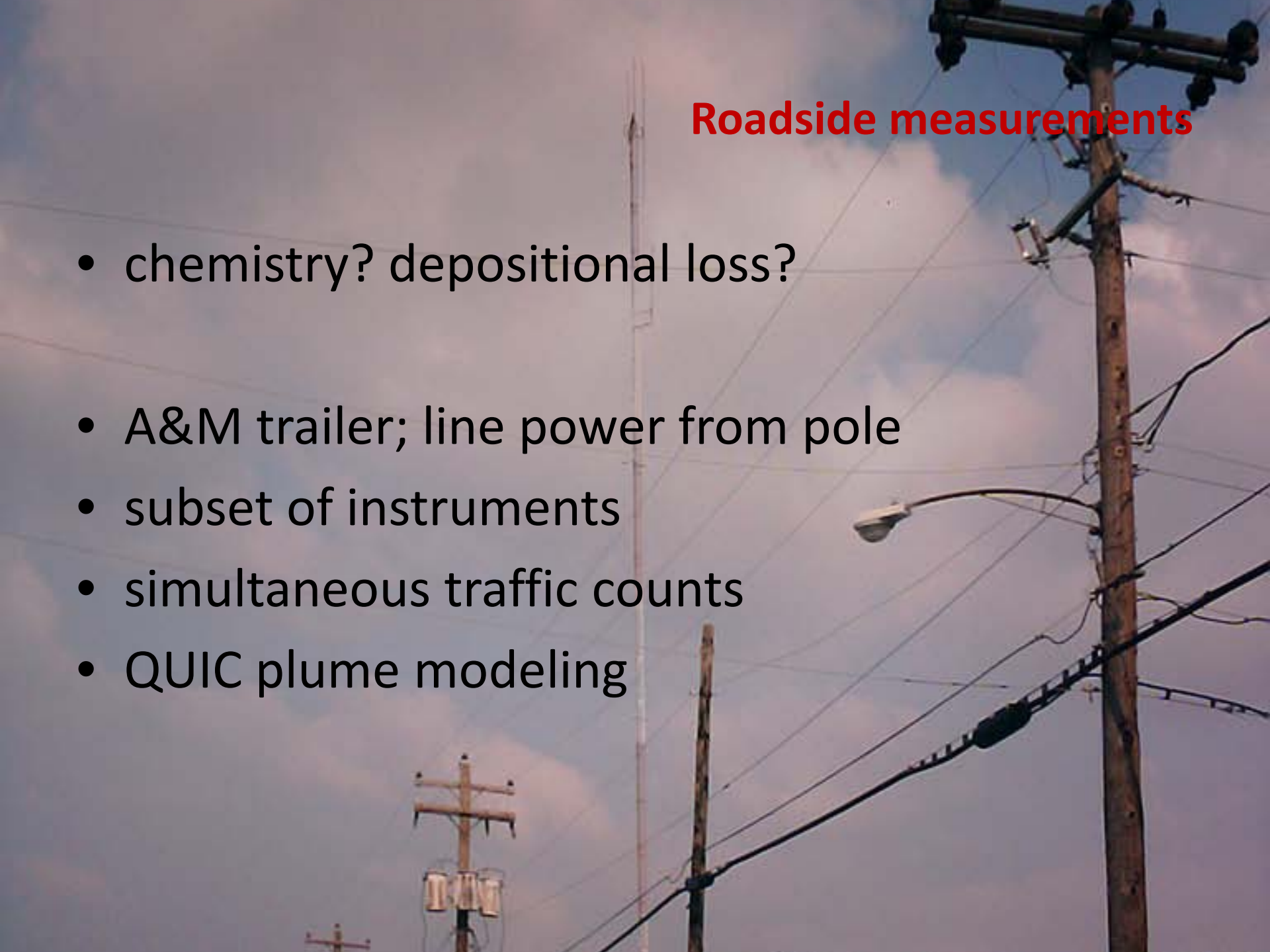
- GIS data
- footprint models overlay
- ground survey of sources
- tracer release experiment

Modeling, II

- Source apportionment
  - concentration AND flux data
  - CMB and PMF methods
- MOBILE6 vs. MOVES
- CMAQ episode modeling
  - alternate input based on measurements
  - hindcast optimization

MOBILE6 versus MOVES: Population normalized emission factors with vehicle speed (2-axle vehicles)





Roadside measurements

- chemistry? depositional loss?

- A&M trailer; line power from pole
- subset of instruments
- simultaneous traffic counts
- QUIC plume modeling

Expected Results

- Identify (and characterize) EI short-falls
  - example: missing isoprene and MACR emissions
- Temporal and spatial characterization of emissions, including CP and VOCs
- Improve modeling hindcasts
  - characterize needed EI changes

- **Improve forecasts**

Acknowledgements

- Greater Houston Transportation Company (*Yellow Cab*)
- Texas Air Research Center (TARC)
- EPA
- Bernhard Rappenglück, UH
- TCEQ