Urban land cover type influences CO_2 fluxes within Phoenix, Arizona

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Central Arizona-Phoenix Long-Term Ecological Research CAP LTER

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Abstract

Urbanization not only represents a shift in surface characteristics, but this process also leads to changes in the local energy, water and carbon cycles. Despite their relative small global land area, cities are responsible of more than 70% of the total CO_2 anthropogenic emissions. Several studies have been carried out to try to understand the dynamics of carbon dioxide fluxes (known as Net Ecosystem Exchange, NEE) in urban areas. Nevertheless, the variety of land covers types present in cities hampers our ability to quantify the spatial variations present in NEE. This study was intended to analyze NEE over three different landscapes in the Phoenix Metropolitan Area (PMA). A mobile eddy covariance (EC) tower was deployed in a xeric landscaping, a parking lot and a mesic landscaping. Data was processed according to the standard methods suggested by the carbon flux scientific community. A post-processing quality control, filtering and data gap filling was also applied. Analyses of diurnal, daily and monthly cycles of different landscapes were conducted.

Keywords: *eddy covariance; urban net ecosystem exchange, Phoenix Metropolitan Area*.

Introduction

- Urbanization is expected to impact water, energy and carbon fluxes particularly if large changes are made to the pre-existing environment.
- Carbon dioxide exchange over an urban ecosystem is often dominated by fuel combustion from vehicles, industry and buildings rather than plant biological processes.
- Over the last decades, the Eddy Covariance (EC) technique has widely used to assess the surface-atmosphere exchange of CO_2 or NEE over natural ecosystems.
- The objective of the present study was to analyze and estimate NEE over different urban landscapes across the Phoenix Metropolitan Area.

Materials and Methods

Table 1. Instrumentation at mobile EC tower, including number of sensors in parentheses*.

Instrument/model	Manufacturer	Variable measured
Tower		
3D sonic anemometer/CSAT3 (1)	Campbell Scientific	Three-dimensional wind velocities, virtual sonic temperature
Infrared gas analyzer/LI-7500A (1)	Li-Cor Biosciences	Water vapor and carbon dioxide concentrations
Temperature and relative humidity sensor/HMP155A (3)	Vaisala	Air temperature and relative humidity
Four component net radiometer/CNR4 (1)	Kipp & Zonen	Incoming and outgoing shortwave and longwave radiation
Pyranometer/SP-110 (1)	Apogee Instruments	Total shortwave radiation
Barometer/CS100 (1)	Setra Systems	Barometric pressure
Near ground level		
Rain gauge/TE525MM (1)	Texas Electronics	Precipitation
Infrared radiometer/SI-111 (1)	Apogee Instruments	Surface temperature
Below ground level		
Soil heat flux plate/HFP01SC (1)	Hukseflux	Ground heat flux
Soil averaging thermocouple/TCAV (2)	Campbell Scientific	Soil temperature
Water content reflectometer/CS616 (3)	Campbell Scientific	Soil volumetric water content

- Measurements were made during 2015, with three EC tower deployments (Figure 1 and 2).
  - Xeric Landscape (Palo Verde, PV) from January 20th to March 13th
  - Parking Lot (PL) from May 19th to June 30th.
  - Mesic Landscape (turf grass, TG) from July 9th to September 18th.
  - A suburban (SU) permanent tower was used as a reference.

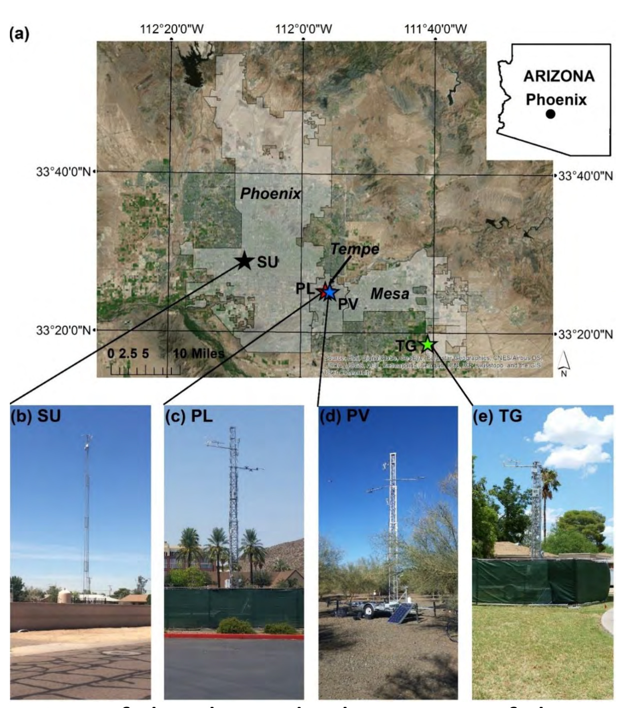

Figure 1. Location of the three deployments of the mobile tower*.

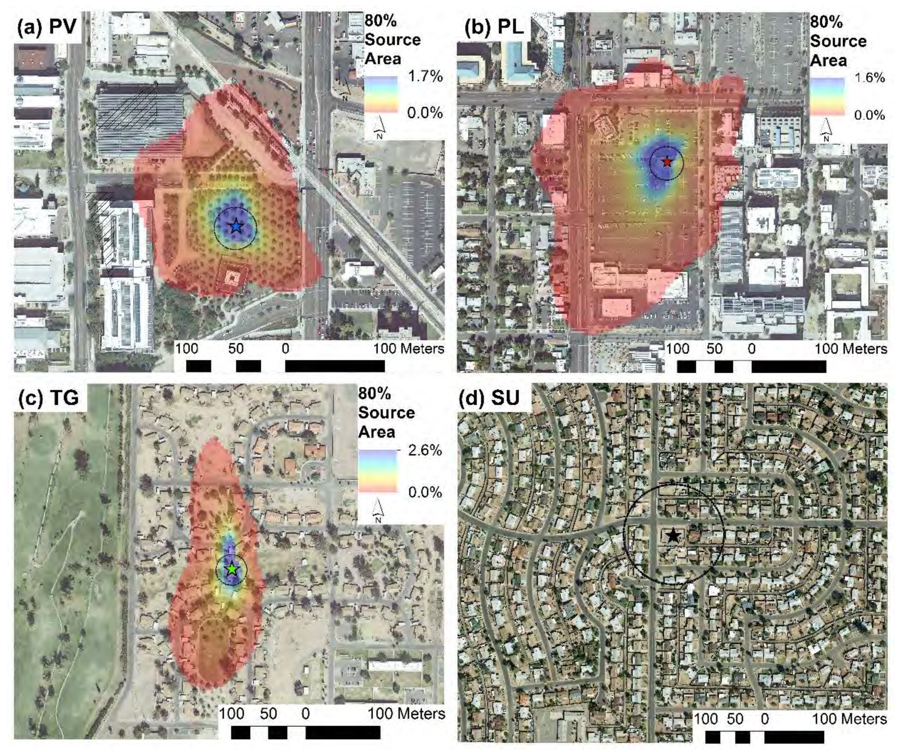

Figure 2. Study site images with the 80% source areas (colored 5 m pixels with percent contribution) and radiometer footprints (black circles) at: (a) PV, (b) PL, (c) TG and (d) SU sites*.

- Analysis of daily, seasonal and diurnal behavior.
- Analysis of Contributing Factor to urban NEE:
  - Anthropogenic (Traffic).
    - Differences between weekdays and weekends.
    - Comparison with traffic counts
  - Biogenic (Vegetation activity).
    - Comparison with NDVI values.
    - Differences between days with low and high incoming shortwave radiation (cloudy and sunny days)

Results

Urban Land Cover	80% Source Area			Radiation Footprint			
	PV	PL	TG	PV	PL	TG	SU
Trees	38.2%	5.9%	16.2%	34.4%	2.2%	6.8%	4.6%
Grass	0.4%	0.7%	28.1%	0.0%	0.7%	43.6%	10.0%
Undeveloped	29.7%	13.9%	34.6%	65.6%	29.6%	34.5%	36.8%
Pavement	8.3%	57.4%	12.8%	0.0%	67.5%	4.1%	22.0%
Buildings or Cement	23.4%	22.1%	8.3%	0.0%	0.0%	11.0%	26.4%
% in 500 m fetch	97.1%	94.5%	96.4%				

Table 2. Urban land cover in 80% source area and radiometer footprint.*,+.

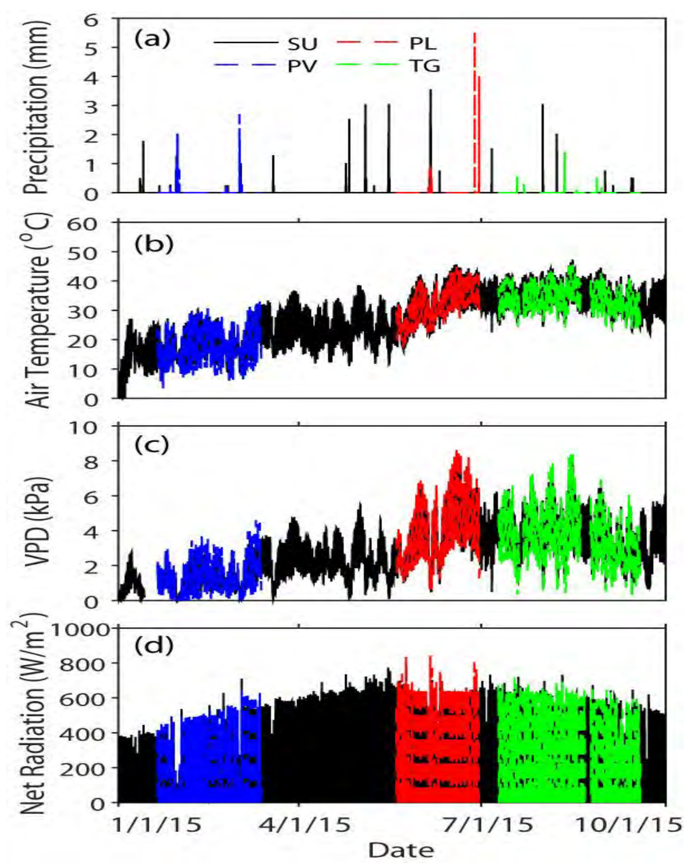

Figure 3. Meteorological measurements for study period (1 January to 30 September, 2015) including: (a) precipitation, (b) air temperature, (c) vapor pressure deficit (*VPD*) and (d) net radiation, shown as 30 min averages*.

Daily, Seasonal and Diurnal fluxes

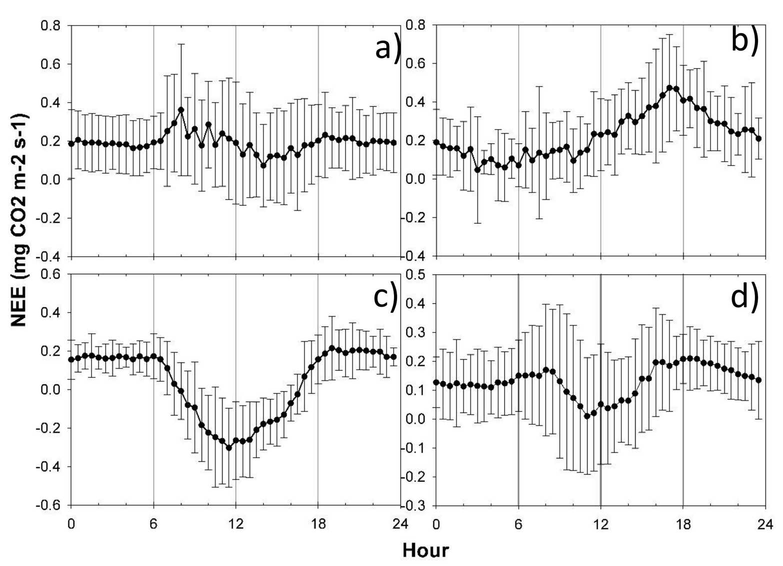

Figure 4. Diurnal averages of urban Net Ecosystem Exchange for the four landscapes. a) XL; b) PL; c) ML; d) REF

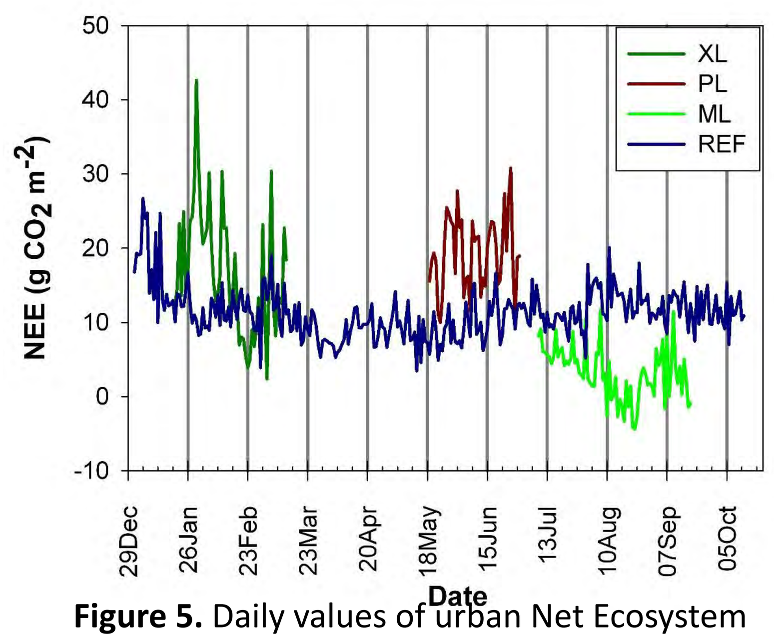

Figure 5. Daily values of urban Net Ecosystem Exchange. Data was processed according to the standards of the flux scientific community

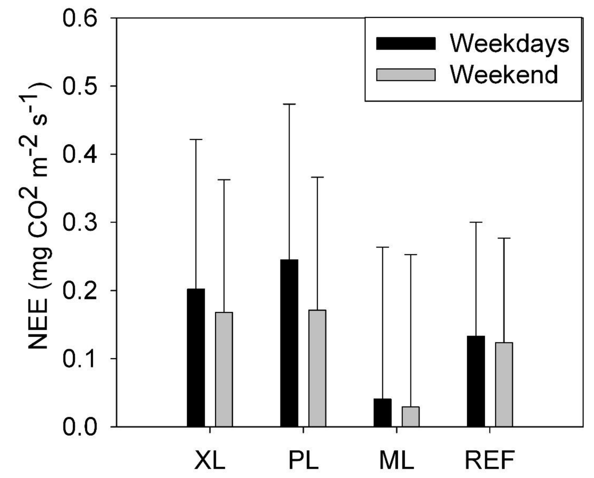

Figure 6. Average NEE for weekday and weekend in the four landscapes

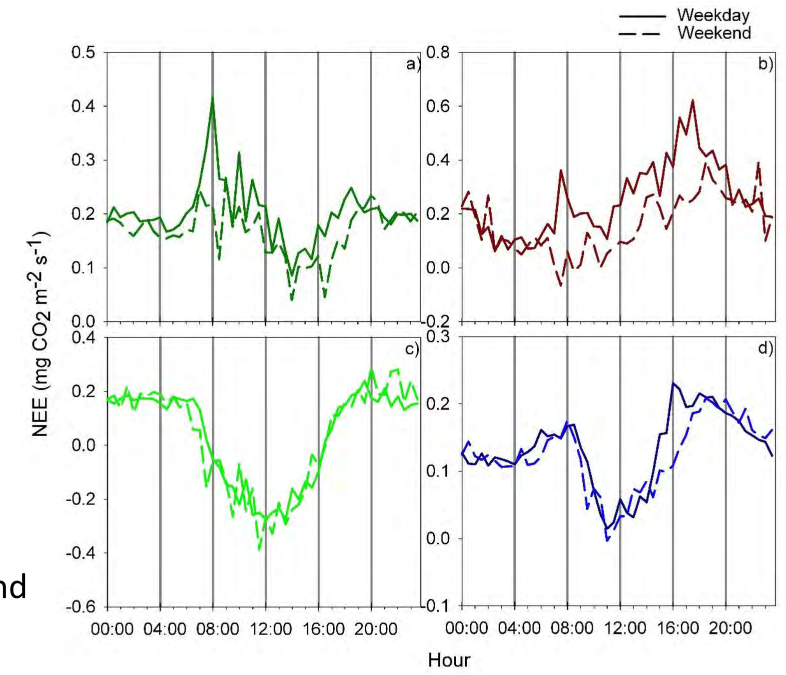

Figure 7. Comparison of diurnal averages between weekdays and weekends. a) XL; b) PL; c) ML; d) REF

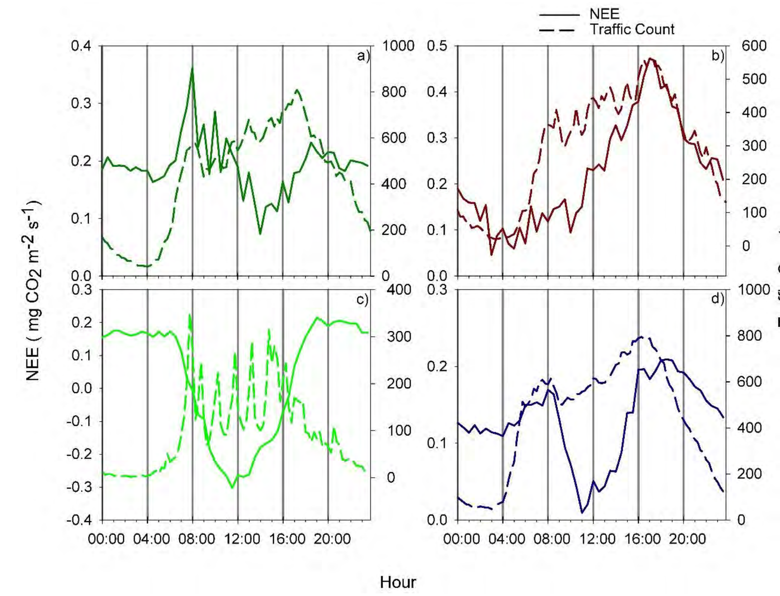

Figure 8. Comparison of traffic counts and diurnal averages of NEE. a) XL; b) PL; c) ML; d) REF

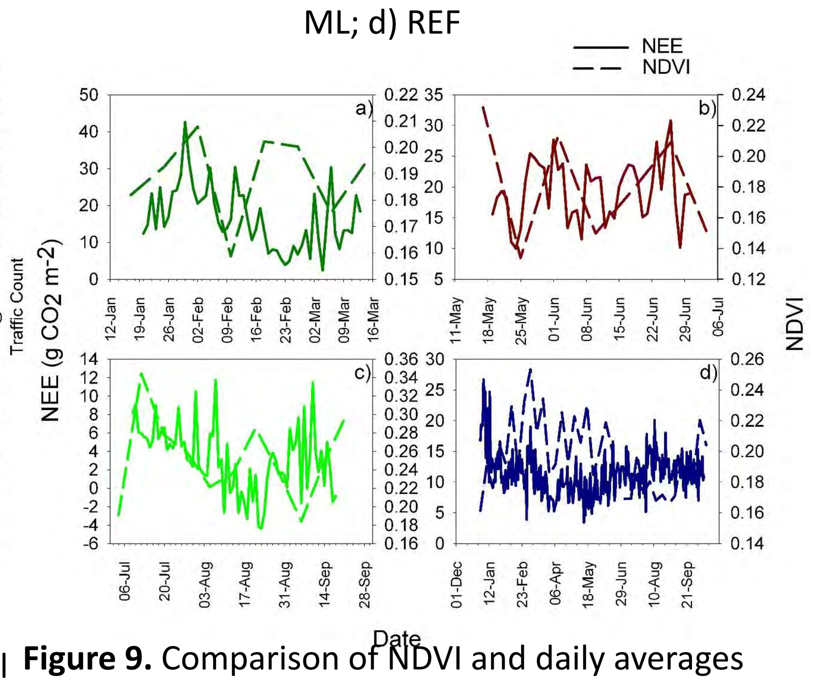

Figure 9. Comparison of NDVI and daily averages of NEE. a) XL; b) PL; c) ML; d) REF

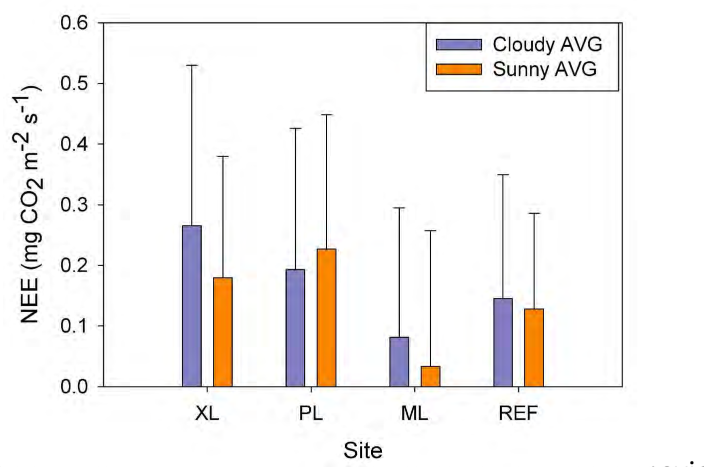

Figure 5. Daily values of NEE (top), monthly diurnal behavio Parking Lot (PL) and

Figure 10. Effect of the incoming shortwave radiation. Comparison of the average NEE for cloudy and sunny days.

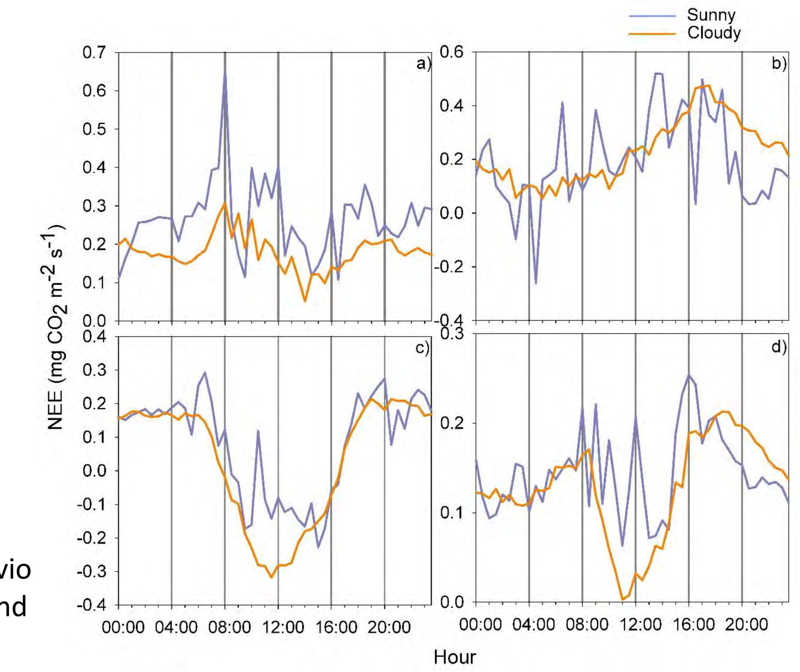

Figure 11. Diurnal averages of NEE for cloudy and sunny days
. a) XL; b) PL; c) ML; d) REF

Conclusions

- Different landscapes measurement showed a different trend in urban NEE on a daily and diurnal basis related to: a) vegetation activity, and b) urban dynamics.
- The presence vegetation had a substantial effect in decreasing NEE during maximum vegetation activity in PV and TG sites, while this effect was not found at the PL site.
- Differences in urban NEE were found between typical business days and weekends, with maximum values during rush hours and a decrease in NEE during the weekends.
- A NEE gradient from a net source of CO_2 in highly-vegetated landscapes to a net sink of CO_2 in a highly-urbanized landscape.
- Characteristics and function of urban patches should have a strong control on the CO2 fluxes within cities, wich can be reliable measured using the EC method.