Variations in Atmospheric Carbon Dioxide Fluxes: Comparison of Urban and Residential Sites in Syracuse, N.Y.

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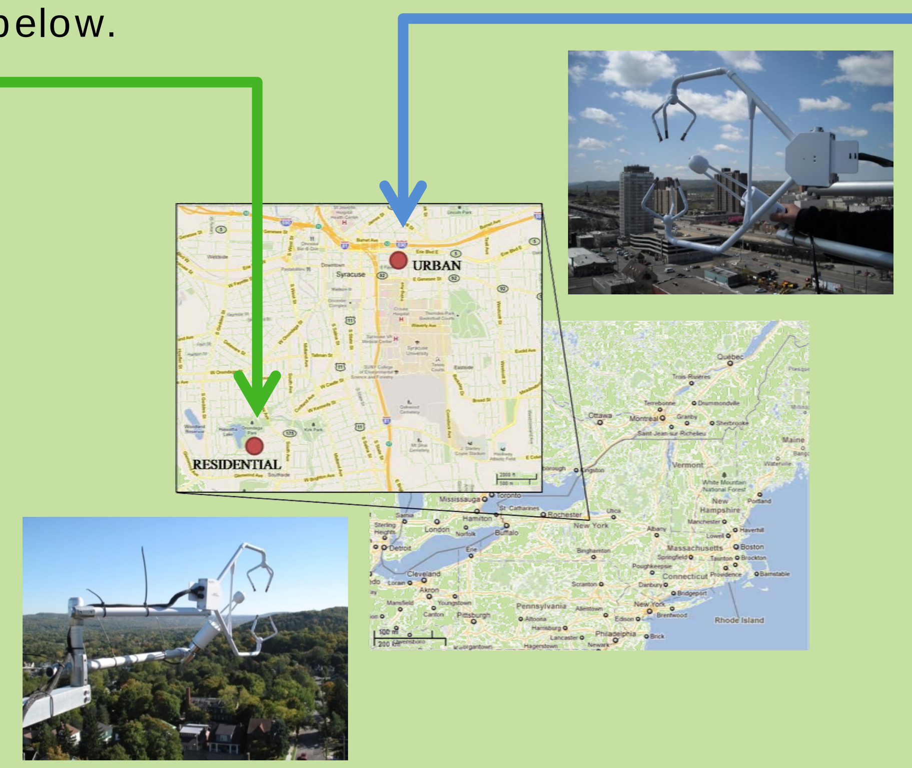
Background:

Urban areas are of great global interest as they are home to a majority of the North American and world population. Although identified as a major contributor of carbon dioxide to the atmosphere, urban areas have been largely neglected in research until recently. As the urban population grows, it is important to understand the sources and sinks of CO_2 so that management and planning within cities can be adapted to minimize negative human and environmental impacts.

Sites:

The Center of Excellence (CoE) **urban** site is located within the commercial downtown area and is within close proximity to Interstate Highways 81 and 690. The tower within Upper Onondaga Park (UOP) is located in a **residential** area southwest of CoE and includes a park and nearby residences. The two ~50 m (150 ft) towers at each site are fitted with the OPEC instrumentation and dataloggers are stored in an adjacent building. Land cover varies widely between sites (Figure 2). More information on both locations is provided in the table below.



	Site Location	Data Range	Elevation	$\overline{z_H}$*	z_d*	z_0*	Surface Cover (1 km radius)	Dominant Wind Direction (Annual)
Urban (CoE)	43.05005 N 76.14048 W	1 June 2010 - 14 April 2011	125 m	10.3 m	8 m	1.0 m	68% Imperv. 15% Tree	W/WNW
Residential (UOP)	43.02392 N 76.16573 W	1 June 2010 – 25 May 2011	164 m	8.4 m	3.5-4.0 m	0.75 m	33% Imperv. 32% Tree	W/WNW

* z_H is mean building height; z_d is zero-plane displacement length estimate; z_0 is roughness length estimate. Estimates of z_d and z_0 are from Grimmond and Oke (1999), with urban location considered to have medium to tall height and density and residential location characterized by low to medium height and density.

Methods:

Data were collected from an open path eddy covariance system (OPEC: CSAT3- Campbell Scientific and LiCOR 7500- LiCOR Biosciences) at 10 Hz. Fluxes were calculated in 30 minute periods in EdiRe software (http://www.geos.ed.ac.uk /abs/ research/ micromet/EdiRe/), with WPL density (Webb et al., 1980) and double rotation corrections. Following flux calculations, data were removed when stationarity tests resulted in values greater than 60%, when wind directions were between 0 and 45º (directly behind CSAT head), and upon manual inspection.

Figure 1

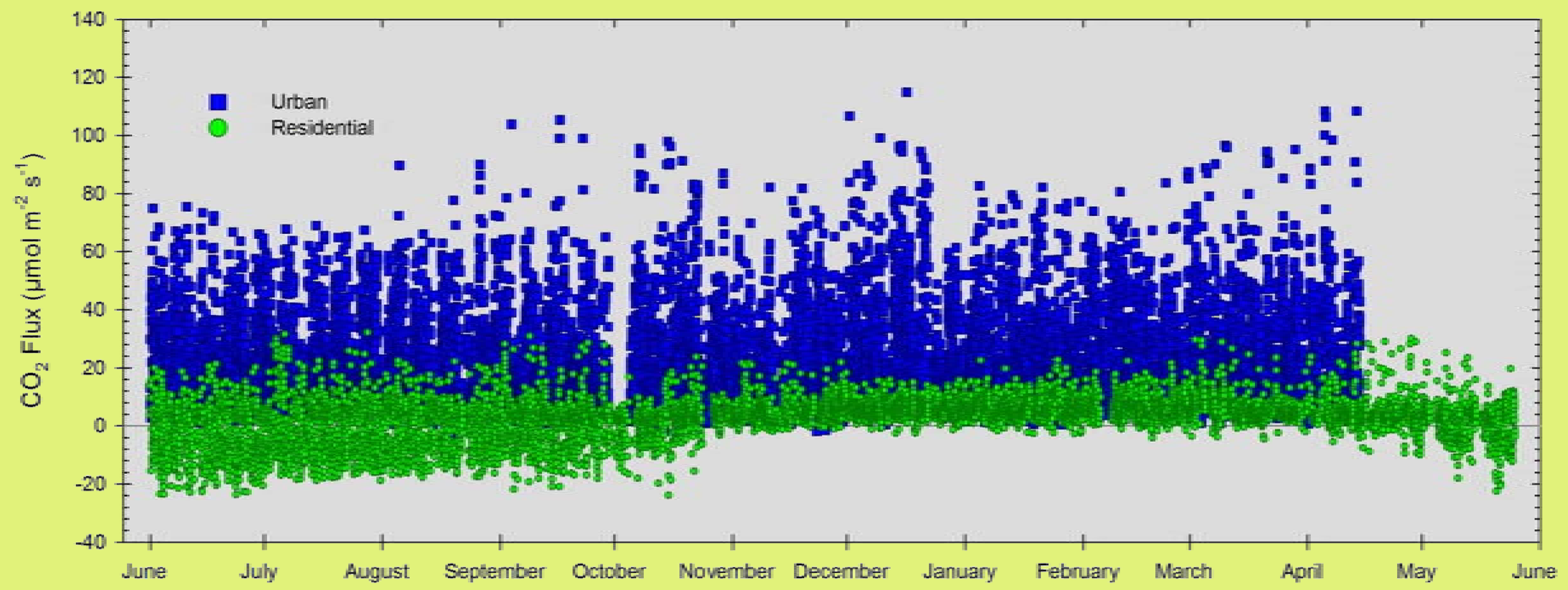


Figure 2

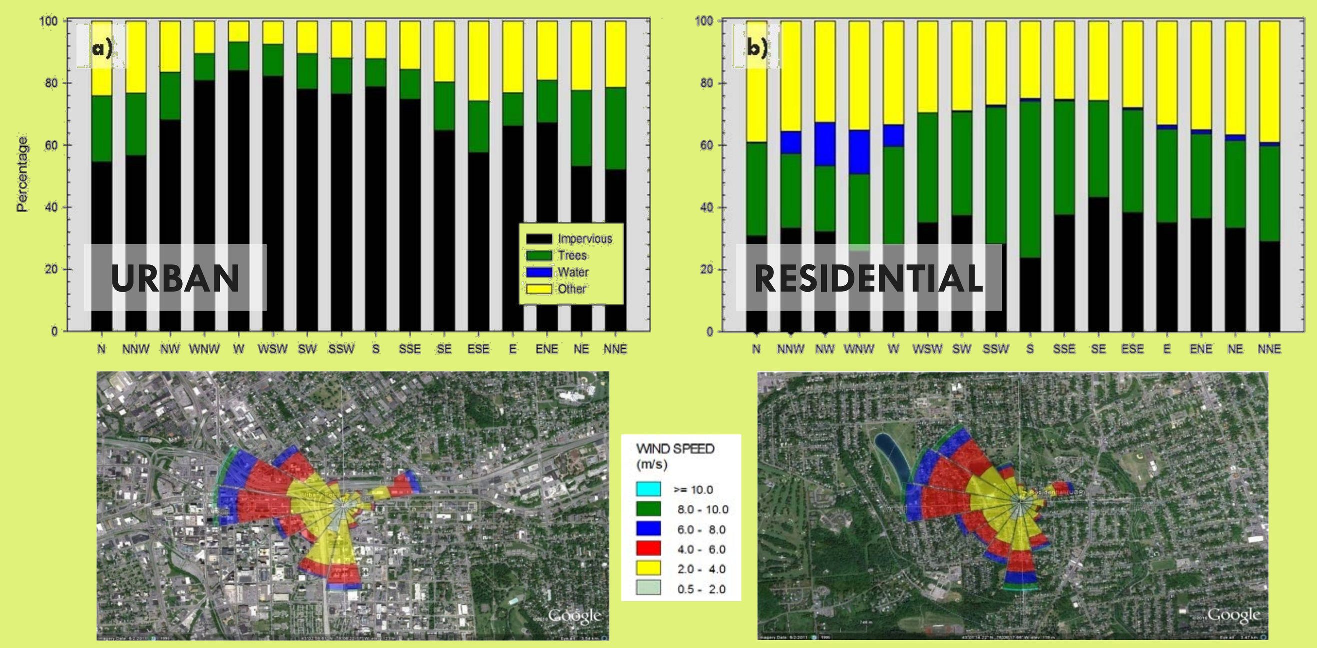


Figure 1, above: Time series of carbon flux data at urban (blue) and residential (green) sites from June 2010-May 2011.

Figure 2, left: Land cover data for a 1 km radius around towers at urban (a) and residential (b) locations. Impervious surfaces include buildings, and pavement, "other" includes grass and dirt cover. Also included are annual windroses overlaid on an areal image of each location (images from Google Earth).

Figure 3

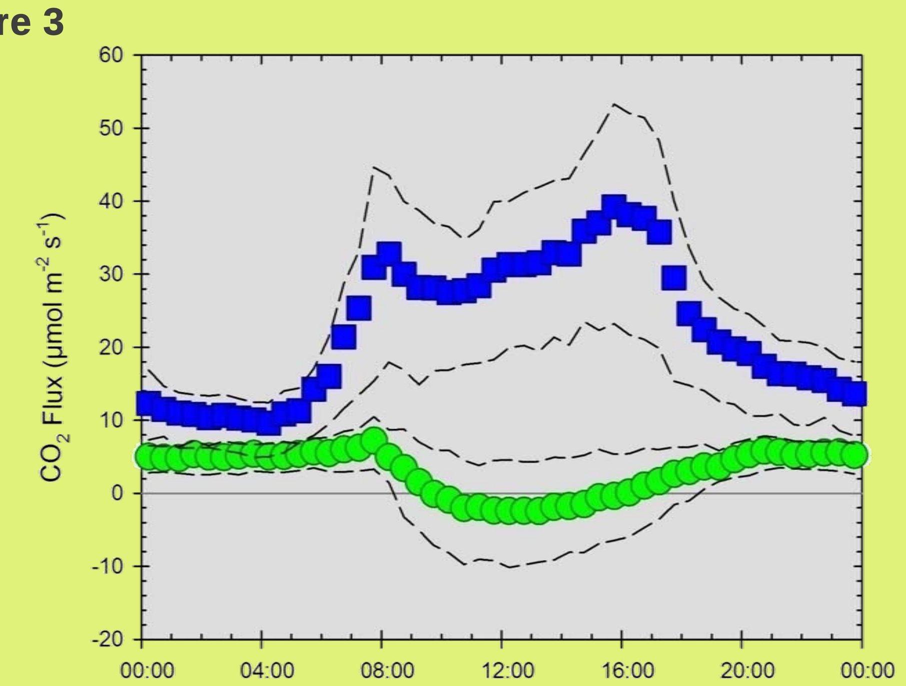


Figure 4

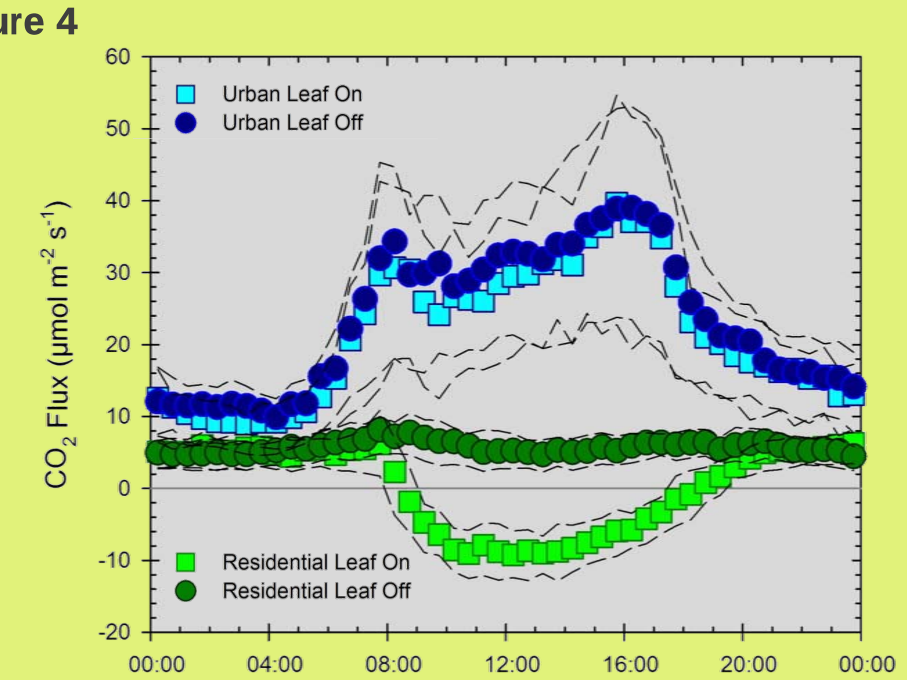


Figure 5

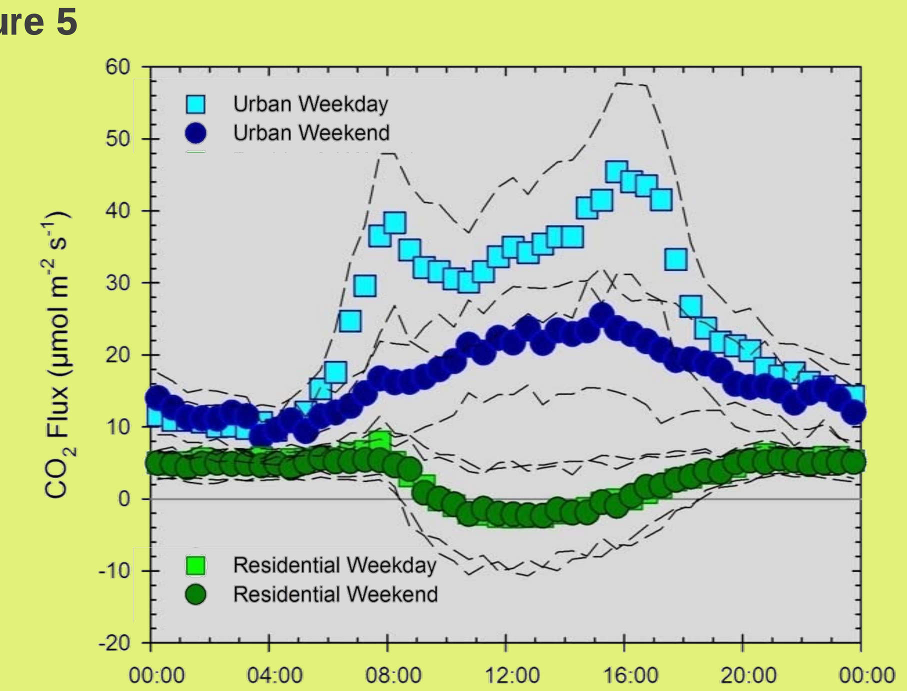


Figure 3, above left: Thirty minute, annual, diurnal averages at urban (blue) and residential (green) locations. Dashed lines indicate IQR.

Figure 4, above right: Diurnal trends of carbon fluxes during leaf on (squares) and leaf off (circles) periods at urban (blue) and residential (green) locations. Leaf on includes data from 1 May – 20 October and the leaf off period includes 21 October – 30 April. Dates determined by images from residential location.

Figure 5, right: Weekly patterns for the urban (blue) and residential (green) locations during weekdays (squares) and weekends (circles).

Figure 6

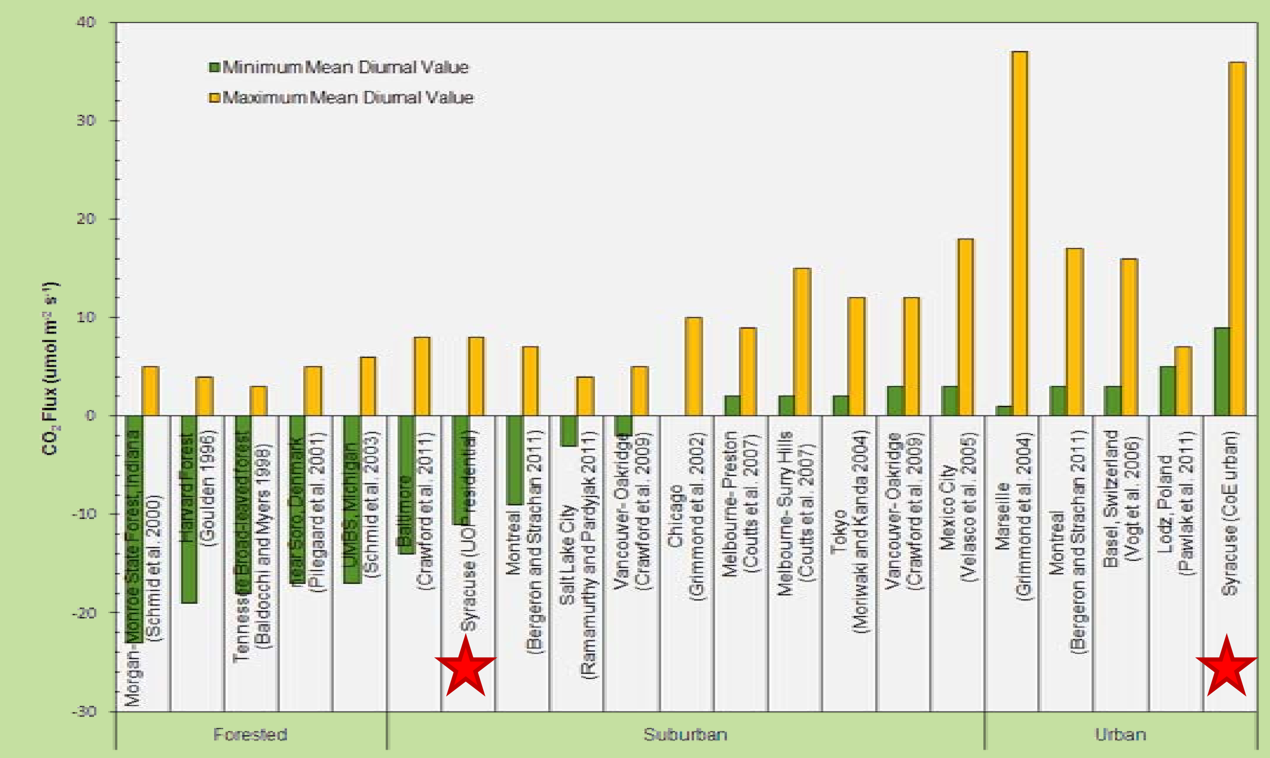


Figure 6, left: Minimum and maximum mean summertime diurnal flux values for urban studies to date. Forested systems included for reference. The results in Syracuse show highly divergent trends within a small area, indicating influence of local land use.

Results:

-**spatial differences** between sites (Figure 1). Urban site rarely experienced negative fluxes, and showed minimal seasonal differences (Figure 4), compared to the residential site, 3.5 km away , which showed strong sinks and seasonal differences.

-distinct **differences in land cover** between locations (Figure 2).
- **Urban**: 68% impervious, 15% tree, and 17% other
- **Residential**: 33% impervious, 32% tree, 32% other, and 3% water
- Dominant wind direction (W/WNW) at urban site includes interchange of I-81 and 690.

-**strong diurnal cycles** in CO_2 fluxes at both sites (though in opposite directions): during midday, the **urban** site experienced large positive fluxes while the **residential** site had large, negative fluxes (Figure 3)

- **traffic influence** during weekdays at the **urban** location during morning (08:00 LST) and evening (16:00 LST) rush hours (Figure 5)

-the **residential** site is among the largest vegetation sinks recorded within a suburban area, comparable with some forested systems during the summer (Figure 6)
- this pattern weakens during the leaf off period (Figure 4)

-the **urban** site experienced one of largest maximum mean value in studies to date (Figure 6), likely due to the close proximity to I-690 and I-80, and high percentage of impervious surfaces surrounding the urban tower (Figure 2).

Reference:

Grimmond, CSB and TR Oke. 1999. Aerodynamic properties of urban areas derived from analysis of surface form. *Journal of Applied Meteorology*, 38: 1262-1292.

Webb, EK, GI Pearman, and R Leuning. 1980. Correction of flux measurements for density effects due to heat and water vapour transfer. *Quarterly Journal of the Royal Meteorological Society*, 106: 85-100.

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