Variations of atmospheric CO_2 at urban and residential sites within the City of Syracuse in New York State (USA)

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Introduction:

Urban areas are of great global interest with over 75% of the population in North America (Pataki et al. 2007), and just over half of the world's population, now residing in cities (UNFPA 2007).   As cities continue to grow, they will not only be faced with the challenges associated with climate change, but they will also play a role in the complex meteorology and climatology resulting from the interaction of the built environment that include the urban heat island effect (Oke 1973), aerosol impacts on precipitation (Collier 2006), cooling effects related to vegetation (Grimmond et al. 2002), and adversely impacting human health though increased exposure to pollutants and high temperatures (Kuttler 2008).

With the recent announcement by the EPA classifying CO_2 and other greenhouse gases as pollutants under the Clean Air Act, monitoring of emissions and ambient concentrations will be essential in determining appropriate regulations. Results on CO_2 dynamics of urban areas are much more limited when compared to information for other areas including agronomic systems and forests (Grimmond et al. 2002; Baldocchi 2003). As the urban population grows, it is important to understand the sources, sinks and influence of CO_2 so that management and planning within cities can be adjusted appropriately to minimize negative human and environmental impacts.

A greater understanding of CO_2 concentrations and fluxes at a local level in urban sites can provide improved insights on specific sectors on which we can focus emissions reduction efforts in the future. 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. As part of a larger project examining air quality of Syracuse, N.Y., concentrations and fluxes of carbon dioxide are being recorded.   We present below preliminary results for the month of June.

Methods:

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 residential site is located with Upper Onondaga Park (UOP) includes a city park and nearby single house residences.   This residential site is approximately 3.5 km to the SW of the urban site. The two ~50 m (150 ft) towers at each site are fitted with the Open Path Eddy Covariance (OPEC) instrumentation and the dataloggers are stored in an adjacent building. Dominant wind direction at both sites is from the SSW (225^{o}).

Data Processing:

Data were collected from an open path eddy covariance system (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/), air density (Webb et al., 1980) and double rotation (Kaimal and Finnigan 1994) corrections. Following flux calculations, data were removed when u*<0.1 and wind directions were from 0-45^{o} (directly behind CSAT head), retaining 95% of data from the downtown site and 91% of data from the residential location. Remaining outliers were removed upon manual inspection. Concentration data were filtered based on elevated AGC values.

Preliminary Results and Discussion:

CO_2 Fluxes:

Our results reveal strong diurnal cycles in CO_2 fluxes at both sites: positive (source) at the downtown location and negative (sink) during the middle of the day at the residential site. This finding is consistent with the influences of traffic volume downtown and vegetation density at the residential location.

Distinct traffic influences are seen during weekdays at the urban location during morning (08:00 EST) and evening (16:00 EST) traffic rush hours (Figure 1b). In addition, there appears to be an afternoon peak (12:00 EST) at residential site, which could be the result of lunchtime traffic (Figure 1c).

CO_2 Concentrations:

Both locations show similar concentrations and diurnal trends (Figure 2a), despite the differences in fluxes. Given the ability of CO_2 to mix well and quickly in the atmosphere, this could indicate that regional sources/sinks are more dominant than those on the local scale. Elevated concentrations during evening rush hour (17:00 EST; Figure 2) are present at both locations, likely the result of increased traffic. The residential location also showed elevated concentrations in the early morning hours (01:00-04:00 EST; Figure 2c). This buildup of CO_2 could be a result of a more stable atmosphere consistent with nighttime conditions, which decrease the influence of regional sources/sinks and increase the local signal.

Future Directions:

The results presented here are only from the month of June 2010. Continued data collection at both sites will allow for the analysis of seasonal and annual patterns. Data analysis by wind direction could help identify any key sources/sinks of CO_2 in the local area at both locations. Footprint analysis of the two locations will also help to identify key players in the movement of CO_2 at both sites. In addition to CO_2, heat and energy fluxes will also be determined.

Vehicle count and traffic pattern information collected at the downtown site, by collaborators at Cornell University, will provide additional data to help account for and validate diurnal patterns and influence of traffic at peak hours at that location.

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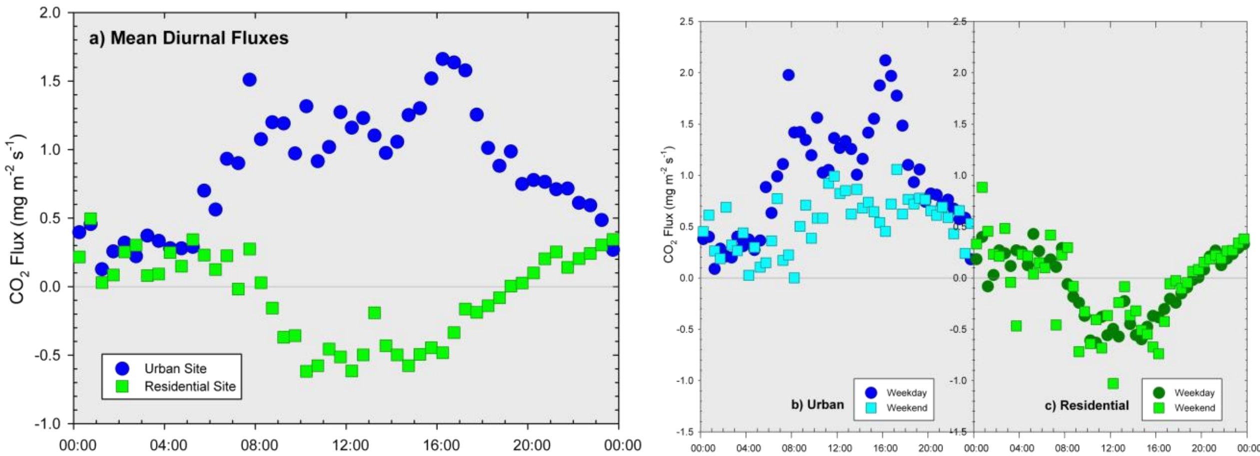

Figure 1: Mean diurnal fluxes for the month of June 2010 (a). Diurnal fluxes divided between weekdays and weekends presented for urban (b) and residential (c) locations.

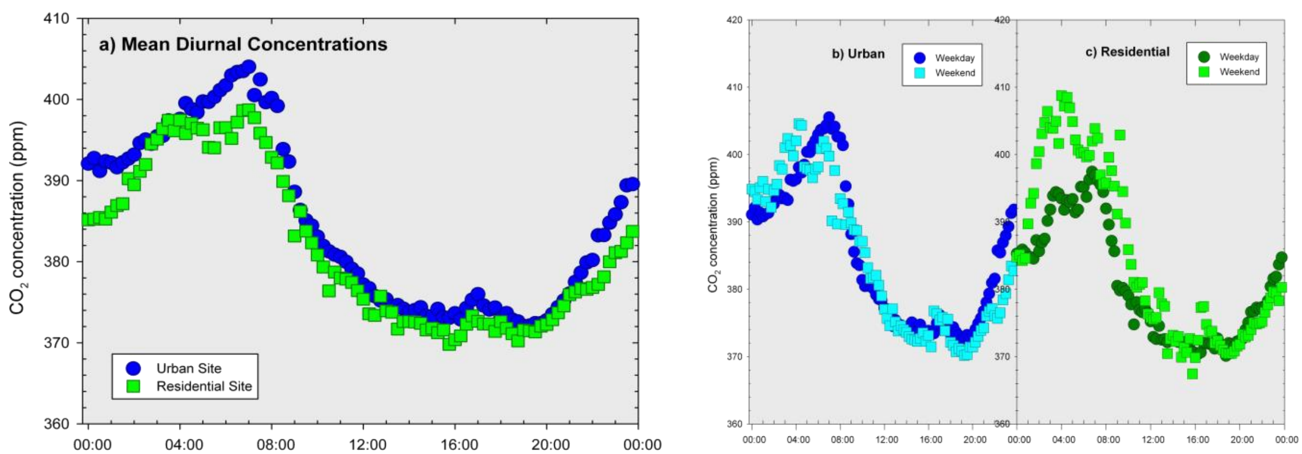

Figure 2: Mean diurnal concentrations for the month of June 2010 (a). Diurnal fluxes divided between weekdays and weekends presented for urban (b) and residential locations (c).