Urban FluxNet: CO_2 - Flux Measurements

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INTRODUCTION

This poster reports the partial results of an ongoing effort to gather information on the availability of flux observations in urban environments. The main goal of this effort is to provide a resource (in the form of a database and a web page) to inform researchers of data that have been collected in the past and/or currently. The database is managed by Sue Grimmond and Danilo Dragoni (Indiana University). It can be accessed via: http://www.indiana.edu/~muhd.

Please note that the data shown in this poster only focus on the network of CO_2-flux observations. They were gathered by contacting those that we knew had conducted observations and a solicitation email to UrbClim email list (www.urban-climate.org). If you know of other studies please contact us.

STUDY SITES

A summary of the locations which have, or are planned to have, urban measurements of CO_2 fluxes is given below. The sites are organized by region with cities in alphabetical order. The Principal Investigator (PI) and other lead scientists in the group are given. The site, or location within the city, is given where it is available.

PI/ Lead scientists	Site	City	85...	94	95	96	97	98	99	00	01	02	03	04	05	....
			IOP	IOP	IOP	IOP	IOP	IOP	IOP	IOP	IOP	IOP	IOP	IOP	IOP	IOP
Hu		Beijing														
Kanda, Moriwaki	Hugahara	Tokyo									May					
Coutts, Beringer, Tapper	Preston	Melbourne											August			
Vogt, Christen	Klingelbergstrasse	Basel														
Vogt, Christen	Sperrstrasse	Basel										Summer				
Scherer	Steglitzer Kreisel	Berlin														
Soegaard		Copenhagen								May						
Nemitz, Fowler		Edinburgh								Oct-Nov						
Kuttler		Essen														
Mayer		Freiburg														
Offerle, Grimmond	Lagiewnicka	Lodz										August				
Offerle, Grimmond	Lipowa (LTM)	Lodz										August				
Grimmond, Oke	CAA	Marseille									July					
Masson		Toulouse											March			
Miglietta	Collegio Romano	Rome												January		
Grimmond, Hom, Crawford	Cub Hill	Baltimore									May					
Grimmond, King	N. Oak Park	Chicago		Summer	Summer											
Anderson	Dartmouth-Santa Fe	Denver														
McFadden	KUOM Tower	Roseville								July						
Oke, Walsh	Sunset	Vancouver									Sept	Dec	late			End 2007

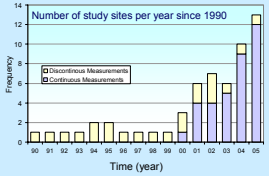
Observation periods: red = discontinuous measurements, green = continuous measurements; IOP = intensive observation period

The earlier observations were short campaigns (e.g. Grimmond et al. 2002, Nemitz et al. 2002). Only recently have longer term campaigns been conducted within urban areas.

To date, there have been more studies in Europe, and more are planned for European cities, than in any other region.

Note that there are more urban areas with observations of CO_2 concentrations.

It is always critical to consider scale as measurements taken close to road level will be quite different to those taken at the local scale. Local scale data typically are taken 2*x height of the roughness elements to ensure that the data are representative of an integrated response of a neighborhood, for example.

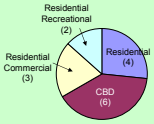


RANGE OF LAND USE TYPES

Within an individual urban area there are typically a number of different land uses. These include for example: residential, commercial, recreational (e.g. parks).

Residential and Recreational	
North Oak Park, Chicago	USA
KUOM tower, Roseville –Minneapolis	USA

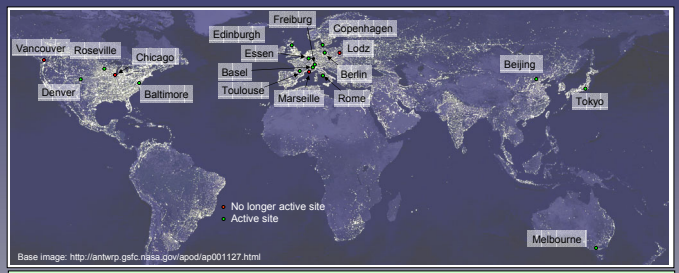
Residential and Commercial	
Dartmouth-Santa Fe, Denver	USA
Sunset, Vancouver (also Institutional)	Canada
Steglitzer Kreisel, Berlin	Germany



(Sites with unknown land use are not included in the count)

Residential	
Kugahara, Tokyo	Japan
Preston, Melbourne	Australia
Lagiewnicka, Lodz	Poland
Cub Hill, Baltimore	USA

CBD	
Beijing	China
Copenhagen	Denmark
Lipowa (LTM), Lodz	Poland
Collegio Romano, Rome	Italy
Toulouse	France
CAA, Marseille	France



RANGE OF URBAN ZONE TYPES

Individual land use types are not the same between regions, or even necessarily within one city. For example, in Europe the Central Business District (CBD) is likely to consist of buildings that are 4-6 stories high whereas in North America the surface is likely to consist of high rises which create a more chaotic surface.

Another way to compare urban areas globally is to use morphometric characteristics. One classification that has been proposed are Urban Climate Zones (UCZ) (Oke 2004) (see table to the right).

To date the predominant UCZ where measurements have been conducted is UCZ=5 (medium development). It is likely that many of the new, and yet unspecified, European sites will be UCZ=2.

Table 1: Simplified classification of distinct urban zone forms arranged in approximate decreasing order of their ability to impact local climate [Oke, 2004 unpublished]

Urban Climate Zone, UCZ*	Image	Rough-ness class*	Aspect ratio*	% Built (Impervi-ous)*
1. Intensively developed urban with detached stone and high-rise buildings with cladding, e.g. downtown towers		8	>2	>90
2. Intensively developed high density urban with 2–5 storey, attached or very close set buildings often of brick or stone, e.g. old city core		7	1.0 – 2.5	>85
3. Highly developed, medium density urban with row or detached but close-set houses, 2–5 storey apartments e.g. urban housing		7	0.5 – 1.5	70 - 85
4. Highly developed, low or medium density urban with large low buildings & paved parking, e.g. shopping mall, warehouses		5	0.05 – 0.2	70 - 95
5. Medium development, low density suburban with 1 or 2 storey house, e.g. suburban housing		6	0.2 – 0.6 (up to 1)	35 - 65
6. Mixed use with large buildings in open landscape, e.g. institutions such as hospital, university, airport		5	0.1 – 0.5, (depends on trees	< 40
7. Semi-rural development, scattered houses in natural or agricultural area, e.g. farms, estates		4	> 0.05, (depends on trees	< 10

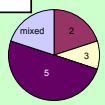
Key to image symbols: buildings, vegetation, impervious ground, pervious ground

* A simplified set of classes that includes aspects of the schemes of Auer (1978) and Ellefsen (1990/91) plus physical measures relating to wind, thermal and moisture controls (columns at right). Approximate correspondence between UCZ and Ellefsen's urban terrain zones is 1(Ex1, Ex6), 2(A1-A4, Ds3), 3(A6, Ds1-5, Ds7), 4 (Ex1, Ex4, Ds4, Ds5), 5 (Ds3), 6 (Ds6, 7 none).

UCZ = mixed	
Steglitzer Kreisel,Berlin	Germany
Dartmouth-Santa Fe, Denver	USA

UCZ = From 2 to 5
3+4

UCZ = 5	
North Oak Park, Chicago	USA
KUOM tower, Roseville - Minneapolis	USA
Cub Hill, Baltimore	USA
Sunset, Vancouver	Canada
Lagiewnicka, Lodz	Poland



UCZ = 2	
Lipowa (LTM), Lodz	Poland
CAA, Marseille	France

UCZ = 3	
Kugahara, Tokyo	Japan

(Sites with unknown UCZ are not included in the count)

Oke, T.R.(2004): IOM Report – WMO, in press

REPRESENTATIVE PUBLICATIONS

To date, there have been only a very few refereed publications published. However there are now several papers in press. In the next few months we will see almost a doubling of publications.

Baltimore
- Grimmond, C.S.B., Offerle, B.D., Hom, J. and Golub, D. (2002): Observations of local-scale heat, water, momentum and CO2 fluxes at Cub Hill, Baltimore. Preprints 4th Urban Environment Symposium, American Meteorological Society, 117-118.

Basel
- Vogt, R., Christen, A., Rotach, M.W., Roth, M., and Satyanarayana, A.N.V.: Fluxes and Profiles of CO_2 in the Urban Roughness Sublayer. *Theoretical & Applied Climatology* (in press)

Chicago
- Grimmond, C.S.B., King, T.S., Cropley, F.D., Nowak, D. and Souch, C. (2002): Local-Scale Fluxes of Carbon Dioxide in Urban Environments: Methodological Challenges and Results from Chicago. *Environmental Pollution* 116, S243-S254

Copenhagen
- Soegaard, H. and Møller-Jensen, L. (2003): Towards a spatial CO_2 budget of a metropolitan region based on textural image classification and flux measurements. *Remote Sensing of Environment* 87, 283-294.

Denver
- Anderson, D.E. and Taggart, J. (2002): Urban ecosystem-atmosphere exchange of carbon dioxide. Abstract. Amer.Meteorol. Soc. 4th Symp. Urban Environ., Amer. Meteor. Soc., Norfolk, VA. May 18-23.

Edinburgh
- Nemitz, E., Hargreaves, K.J., McDonald, A.G., Dorsey, J.R., and Fowler, D. (2002): Meteorological measurements of the urban heat budget and CO_2 emissions on a city scale, *Environ. Sci. Technol.*, 36(14), 3139-3146

Lodz, Poland
- Offerle, B.D. (2003): The energy balance of an urban area: examining temporal and spatial variability through measurements, remote sensing and modeling. Ph.D. Thesis, Indiana University

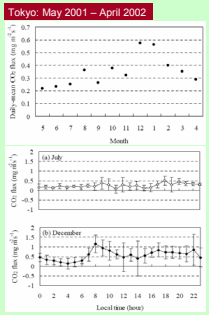
Marseille
- Grimmond, C.S.B., Salmond, J.A., Oke, T.R., Offerle, B., and Lemonsu, A. (2004): Flux and turbulence measurements at a densely built-up site in Marseille: Heat, mass (water and carbon dioxide), and momentum. *Journal of Geophysical Research* 109, in press
- Salmond, J.A. Oke, T.R., Grimmond, C.S.B., Roberts, S. and Offerle, B.D.: Venting of heat and carbon dioxide from urban canyons at night. *Journal of Applied Meteorology* (in review)

Roseville-Minneapolis
- McFadden, J. P., Widboom, A.A., Bauer, M.E. and Yuan, F. (2004): A tall-tower study of carbon exchange from developed land in the U.S. Upper Midwest. American Geophysical Union Fall Meeting. San Francisco, CA, December, 2004

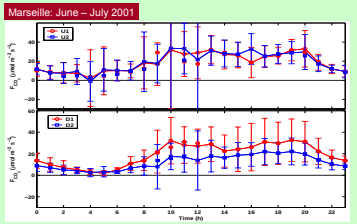
Tokyo
- Moriwaki, R. and Kanda, M. (2004): Seasonal and diurnal fluxes of radiation, heat, water vapor and CO_2 over a suburban area. *Journal of Applied Meteorology* 43, 1700-1710

Vancouver
- Walsh, C., Oke, T.R., Grimmond, C.S.B., Salmond, J.A.: Fluxes of atmospheric carbon dioxide over a suburban area of Vancouver, Preprint for American Meteorological Society (AMS) – 5th Symposium on the Urban Environment, August, 2004,Vancouver, B.C.

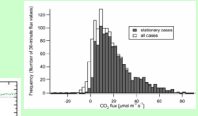
Tokyo: May 2001 – April 2002



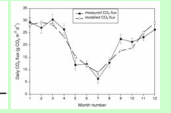
Marseille: June – July 2001



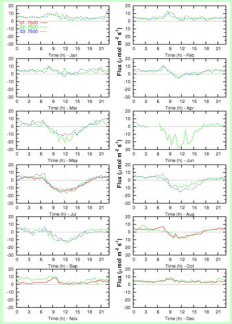
Edinburgh: Oct – Nov 2000



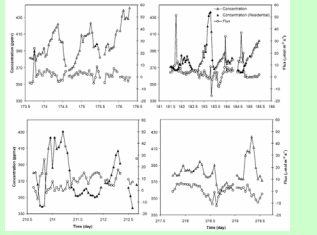
Copenhagen: 2001



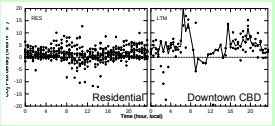
Baltimore: 2001-2003



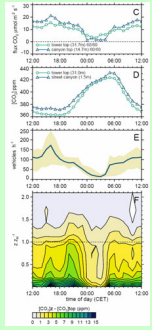
Chicago: Summer 1995



Lodz: August - September 2002



Basel: June – July 2002



The impact of the range of land cover fractions (vegetation:built), and human activities (e.g. vehicle use) on CO_2 fluxes can be seen when comparing across sites. The most dense urban areas are acting as a net source of CO_2 (e.g. Copenhagen, Marseille, Tokyo). However in areas where there are large amounts of vegetation present there is a large sink of CO_2 (e.g. Baltimore) during the summertime which means that these areas may have a close to zero annual balance. To date there have been few studies that have determined the net annual source/sink for their sites.

For references to the sources of the individual site results, see publication list. Obviously in each case there are important details that are needed for complete interpretation of the data presented in these graphs. Note that the units vary between figures.

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