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Eddy Covariance Measurements of CO_2 and CH_4 in Urban Area

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Outline

- Introduction
- Objectives
- Methods
- Results
- Summary

1. Introduction

- CO_2 and CH_4 are the first and second important GHG. And the global warming potential of CH_4 is 25 times that of CO_2 (*Forster et al., 2007*).
- Unlike the carbon cycle in natural ecosystem, the pathway of carbon in urban ecosystem is linear (*Christen et al., 2013*).
- The urban ecosystem is a large CO_2 and CH_4 source to the atmosphere.

1. Introduction

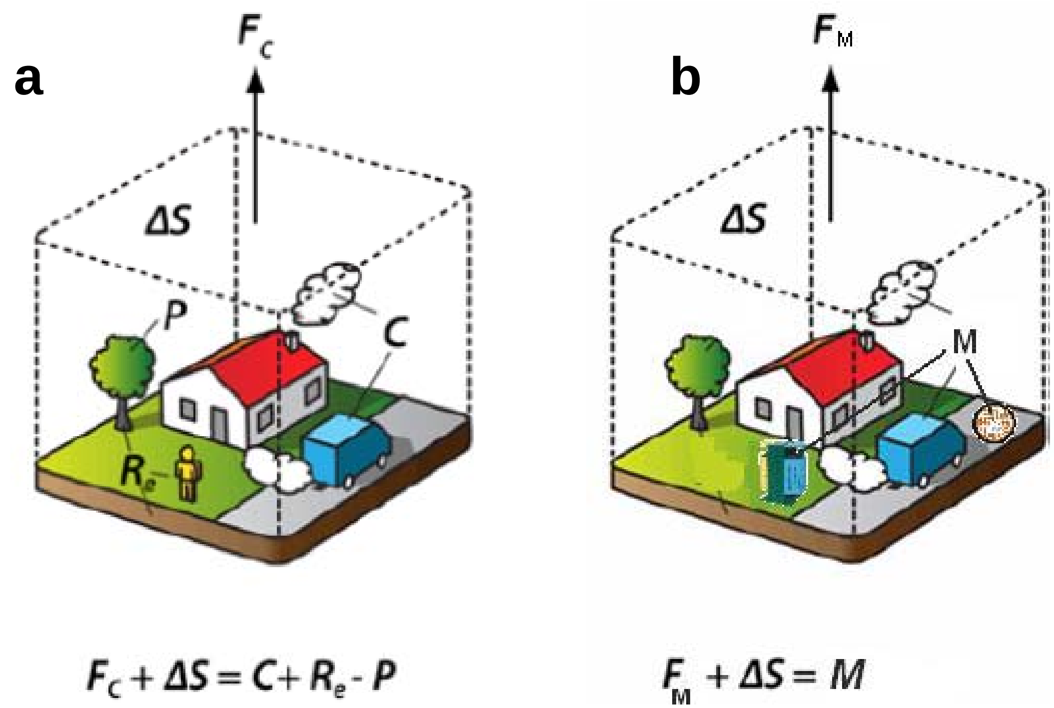


Fig 1. Conceptual chart of the urban (a) CO_2 budget and (b) CH_4 budget (Modified from Feigenwinter et al. 2012).

$$F_c = \overline{w' \rho_c'}$$

$$F_M = \overline{w' \rho_M'}$$

2. Objectives

- Quantify CO_2 and CH_4 exchange between urban surface and the atmosphere, and find their control mechanisms.
- Test urban land surface models.
- Supply data for compiling and evaluating emission inventories.
- The measured flux data can be applied to characterize and parameterize constants in numerical models.

3. Methods

3.1 Measurements

- Eddy covariance (EC) system was composed by 3D sonic anemometer and an open path analyser.

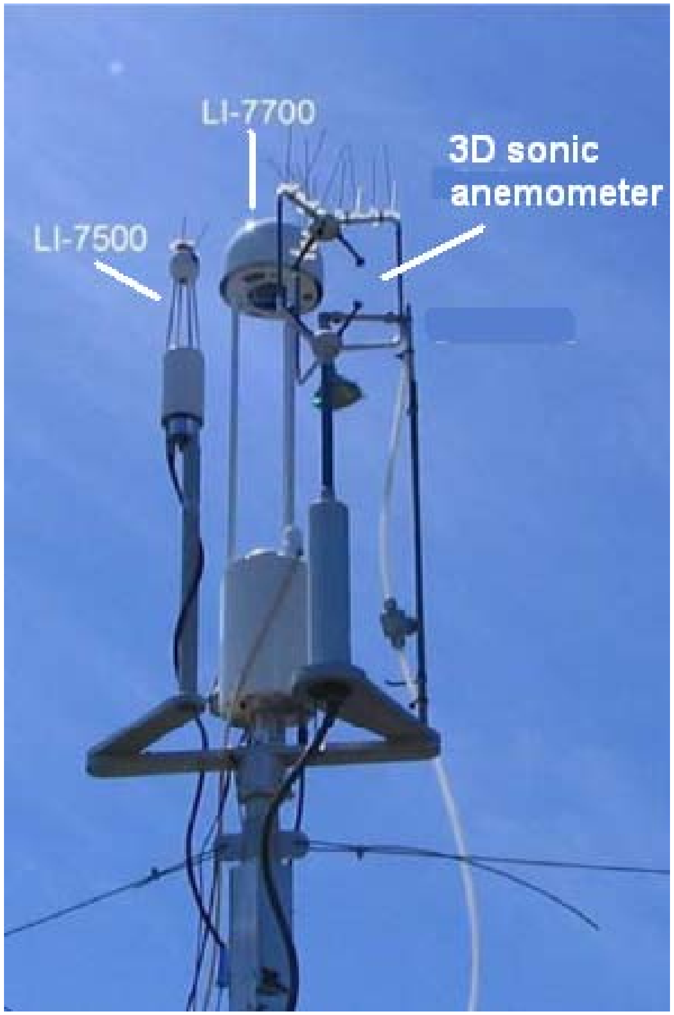


Fig.2 The instruments of EC system

3.2 Sites

- Urban Flux Network includes 47 sites.
- These sites measure energy and material exchange between urban ecosystem and the atmosphere.
- 36 sites have EC system.
- Now, 28 sites still work.

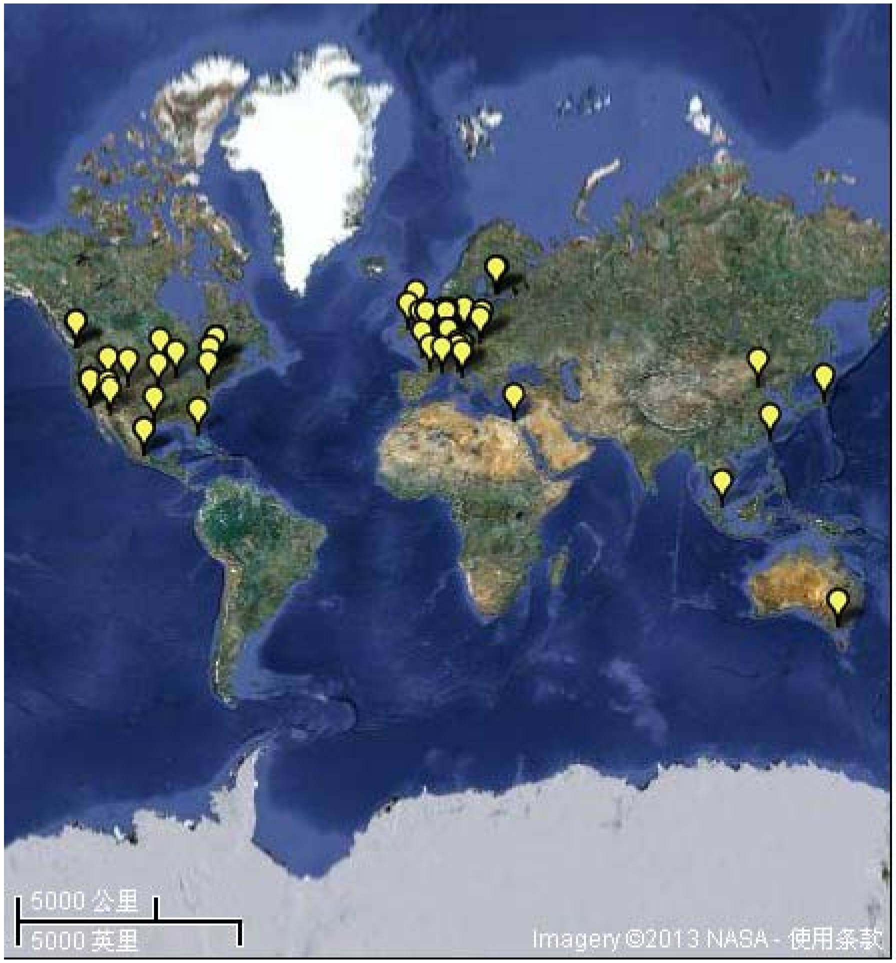


Fig.3 Sites distribution of Urban Flux Network

3.2 Sites

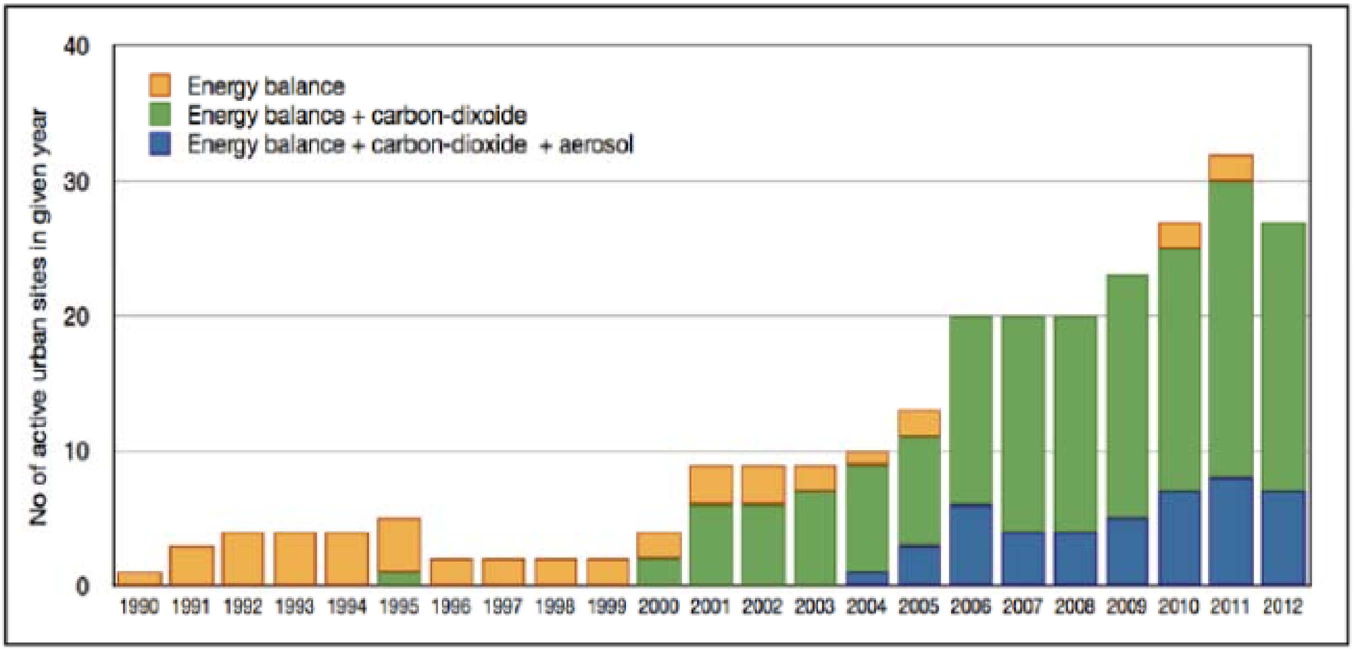


Fig.4 Number of active urban flux sites active per year (1990-2012) and measured turbulent fluxes. Source of data: Urban Flux Network database (*May 2012*).

3.2 Sites

- The characteristics of urban surface must be known.
- The urban surface can be classified two types, vegetation (pervious) and impervious (buildings and paved ground) (*Grimmond et al., 2012*).

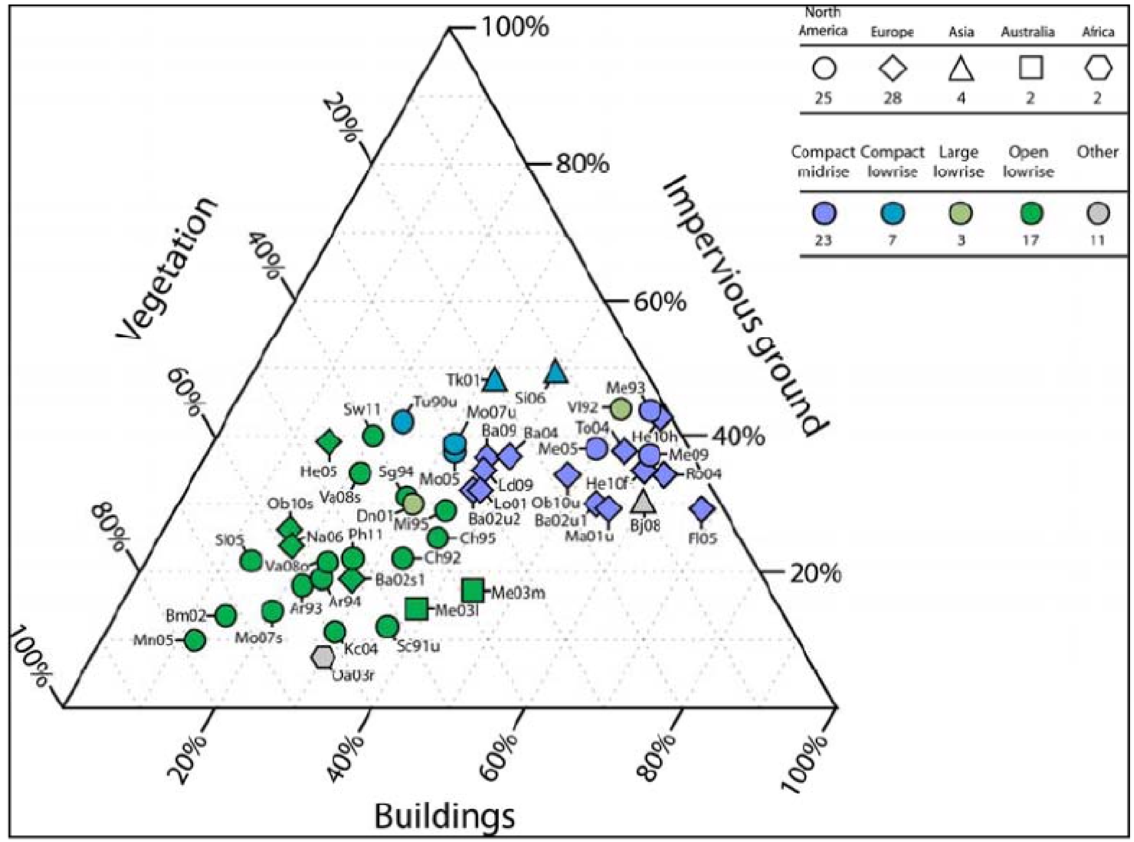
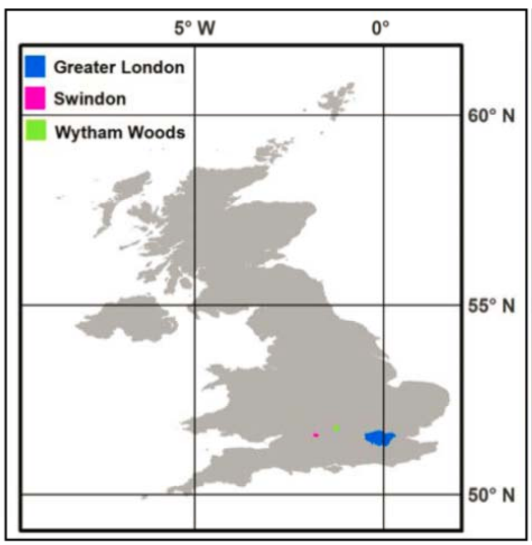


Fig.5 The nature of the urban areas where flux measurements have been undertaken (*Christen et al., 2009*).

3.3 Data processing

(1) A suitable height of measurement

- The measurement height shall be above the blending height.
- EC system are installed facing towards the predominant wind direction.



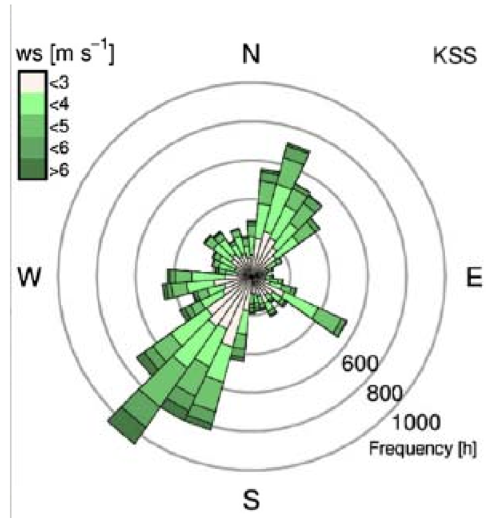



Fig. 6 (a) The location of London site and (b) Frequency distribution of wind speed by wind direction (*Kotthaus et al., 2012*)

3.3 Data processing

(2) Evaluating responses of instrument to turbulence signal

- Spectral and cospectral analysis.

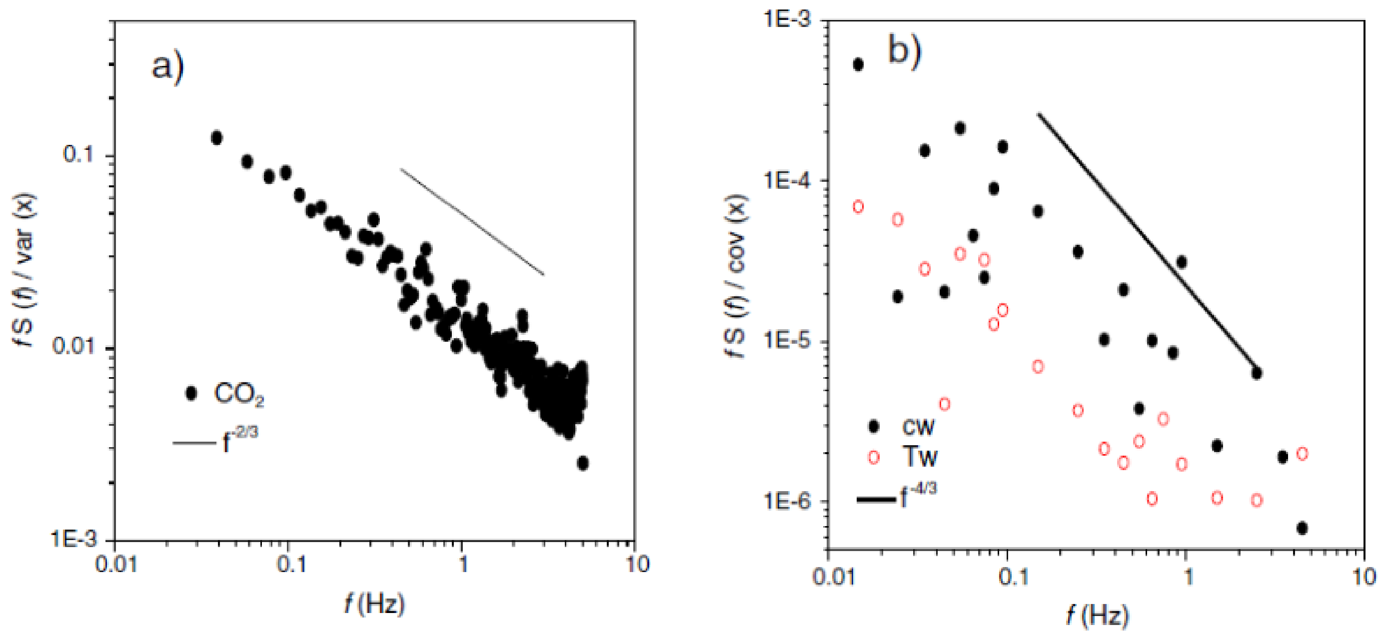


Fig.7 (a) Power density spectra for CO_2 concentration. (b) Cospectra of vertical velocity with CO_2 concentration and ambient temperature at Beijing Site (*Song et al, 2012*)

3.3 Data processing

(3) Footprint of flux

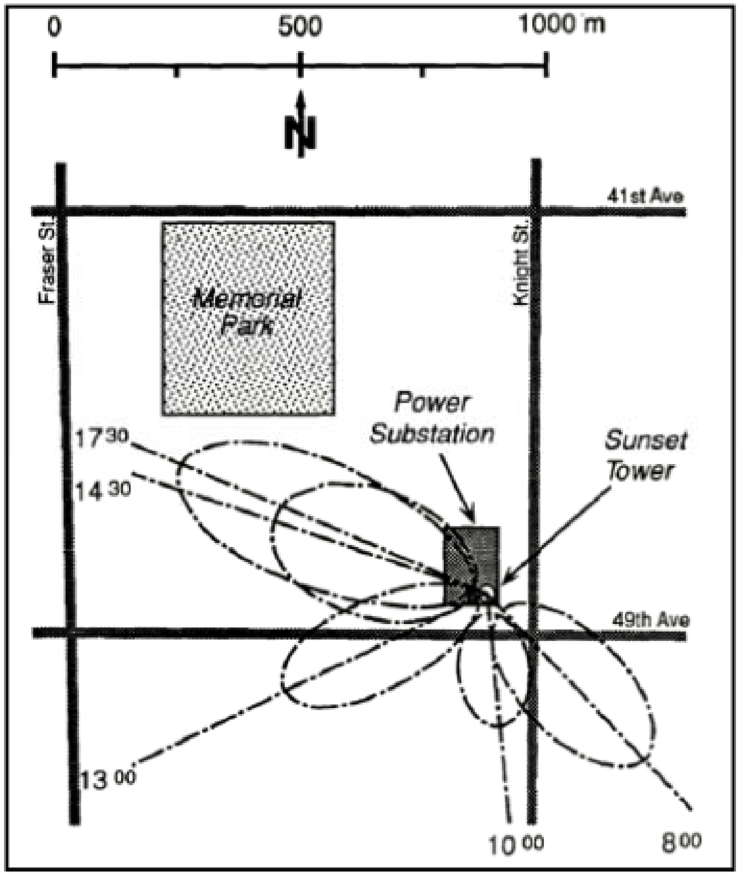
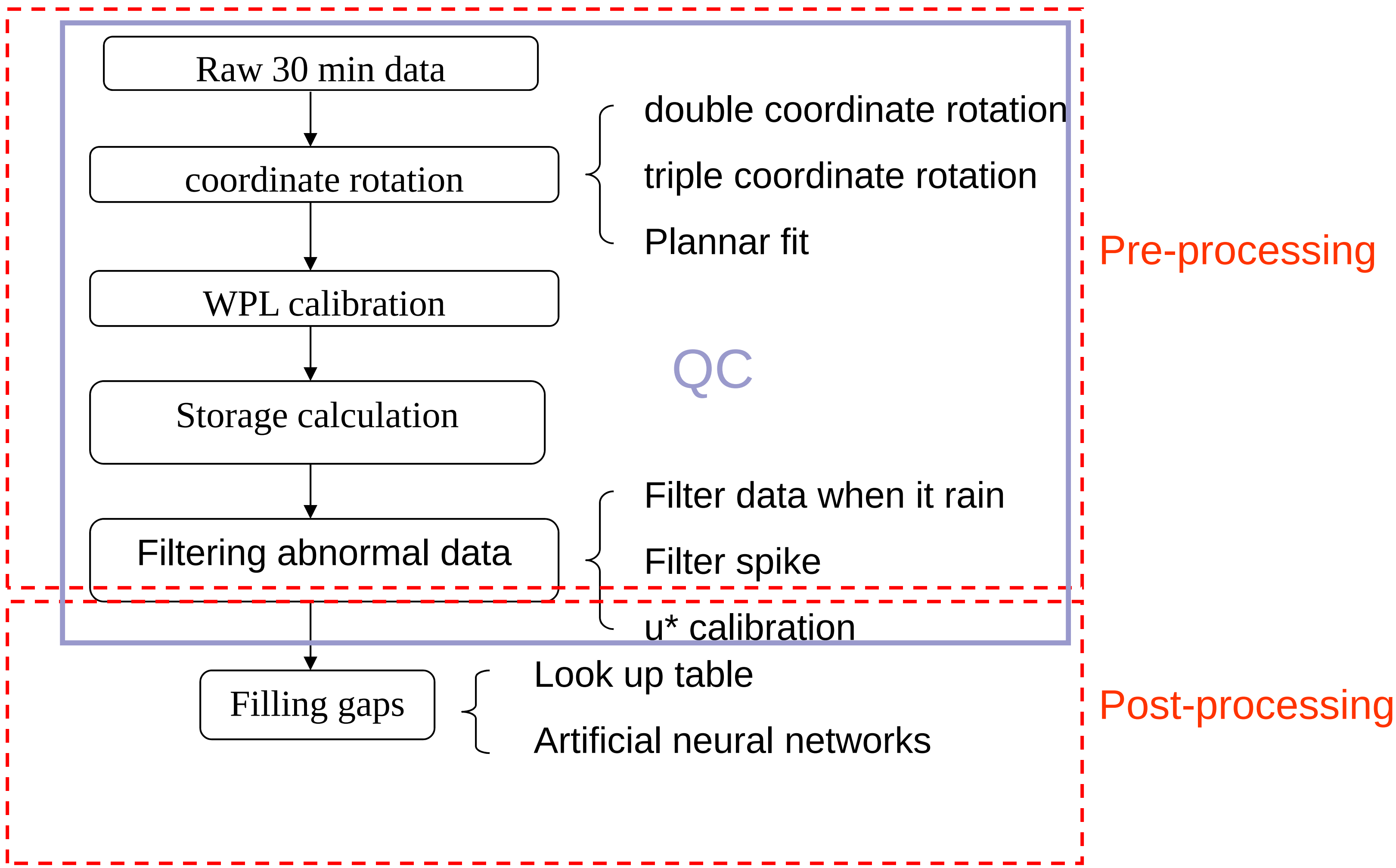


Fig.8 0.5 level isopleths of the turbulent source areas at 'Vancouver-Sunset' for August 19, 1986 calculated by SAM (*Schmid, 1990*).

3.3 Data processing

(4) Pre- and post- processing



4. Results

4.1 CO_2 flux measurment

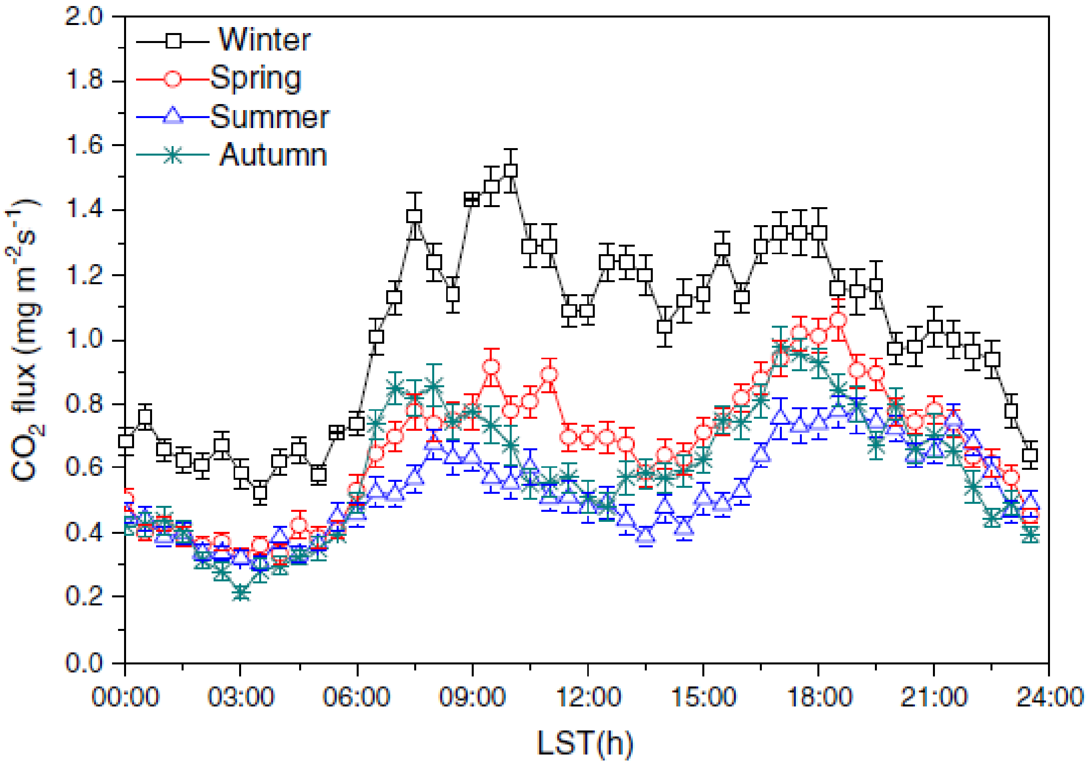


Fig.9 Diurnal course of $_{CO2}$ fluxes of seasonal average at Beijing in 2008. The vertical line indicates the standard error. Standard error is defined as the result of the standard deviation divided by the square root of the sample size (*Song et al., 2012*).

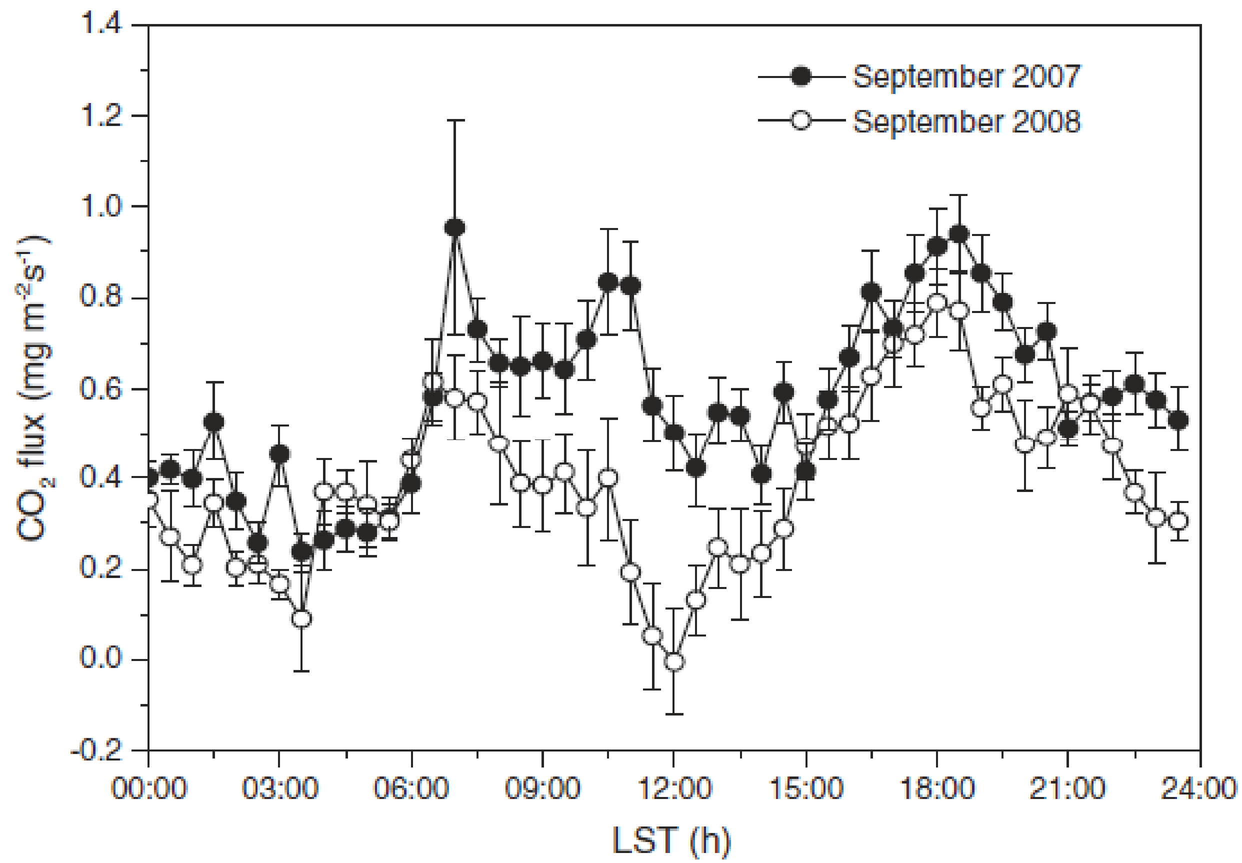


Fig.10 Diurnal courses of CO_2 fluxes of monthly average for September in 2007 and 2008. The vertical line indicates the standard error (*Song et al., 2012*).

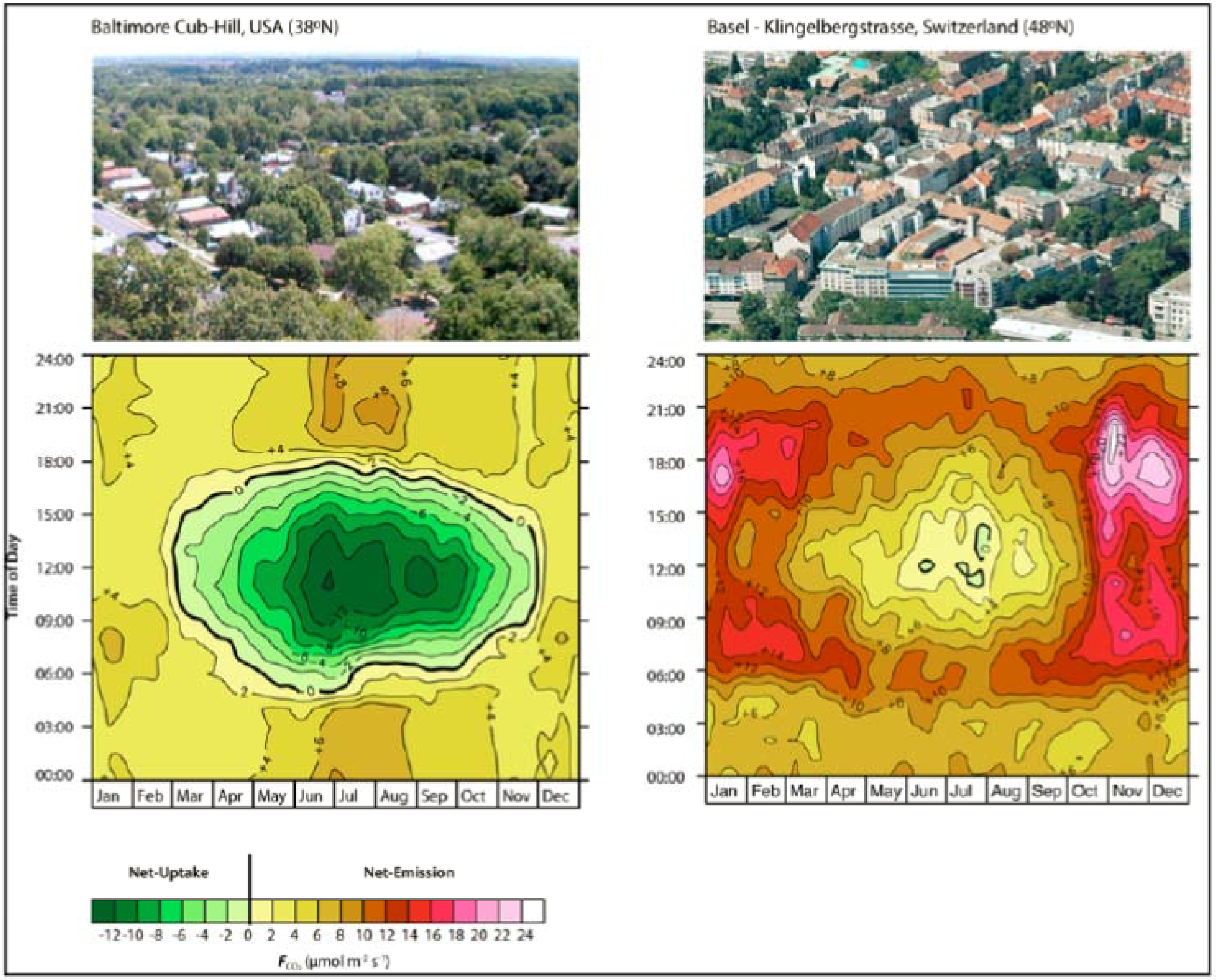


Fig.11 Carbon fluxes by time of day and time of year for a highly vegetated suburban ecosystem in Baltimore, USA (based on data from Crawford et al., 2011) and a dense urban area in central Basel, Switzerland (*based on data from Vogt et al., 2009*).

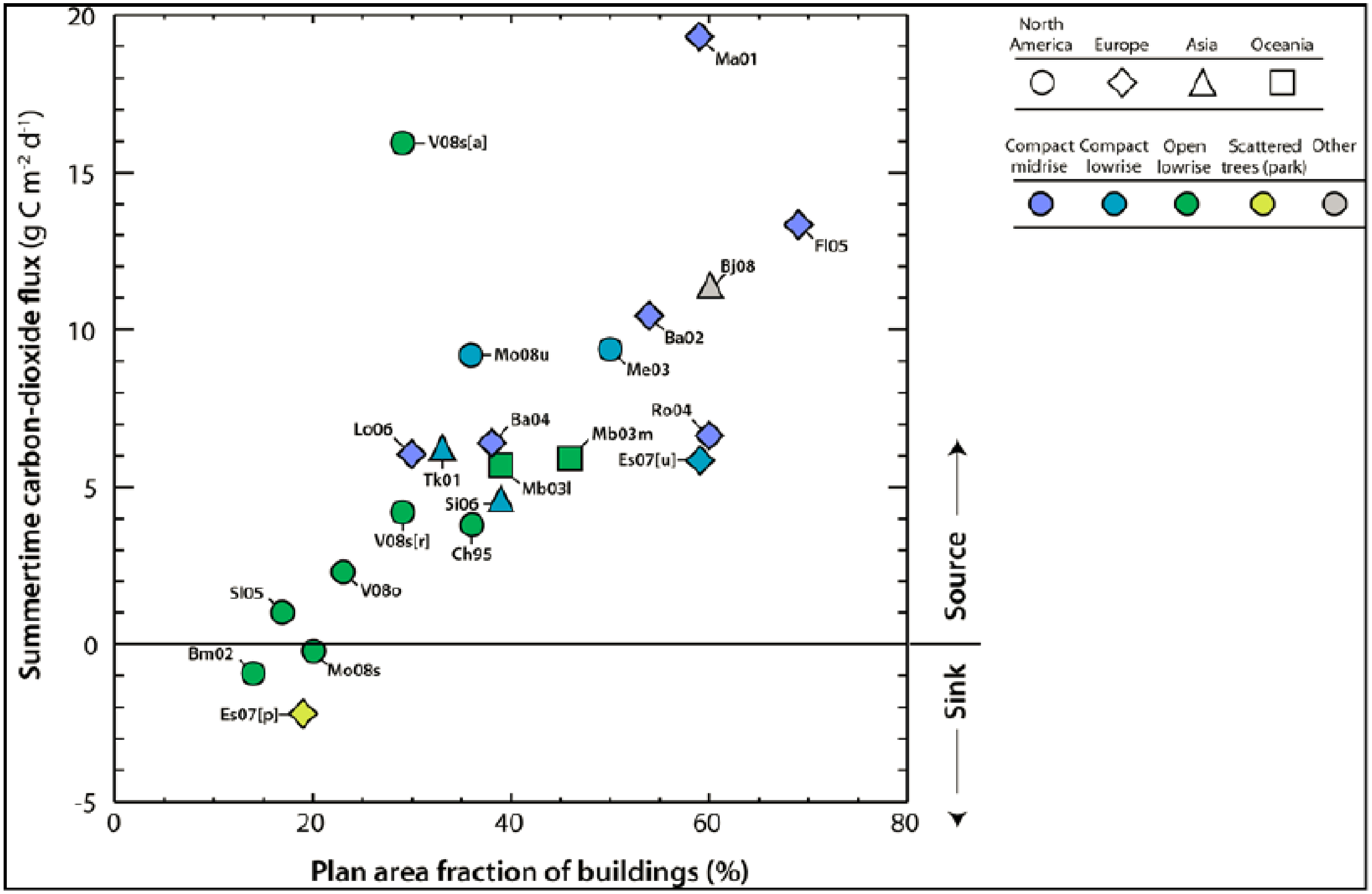


Fig.12 Summertime carbon-dioxide fluxes measured in different urban ecosystems as a function of urban density (expressed as plan area fraction of buildings) (*Christen et al., 2009*).

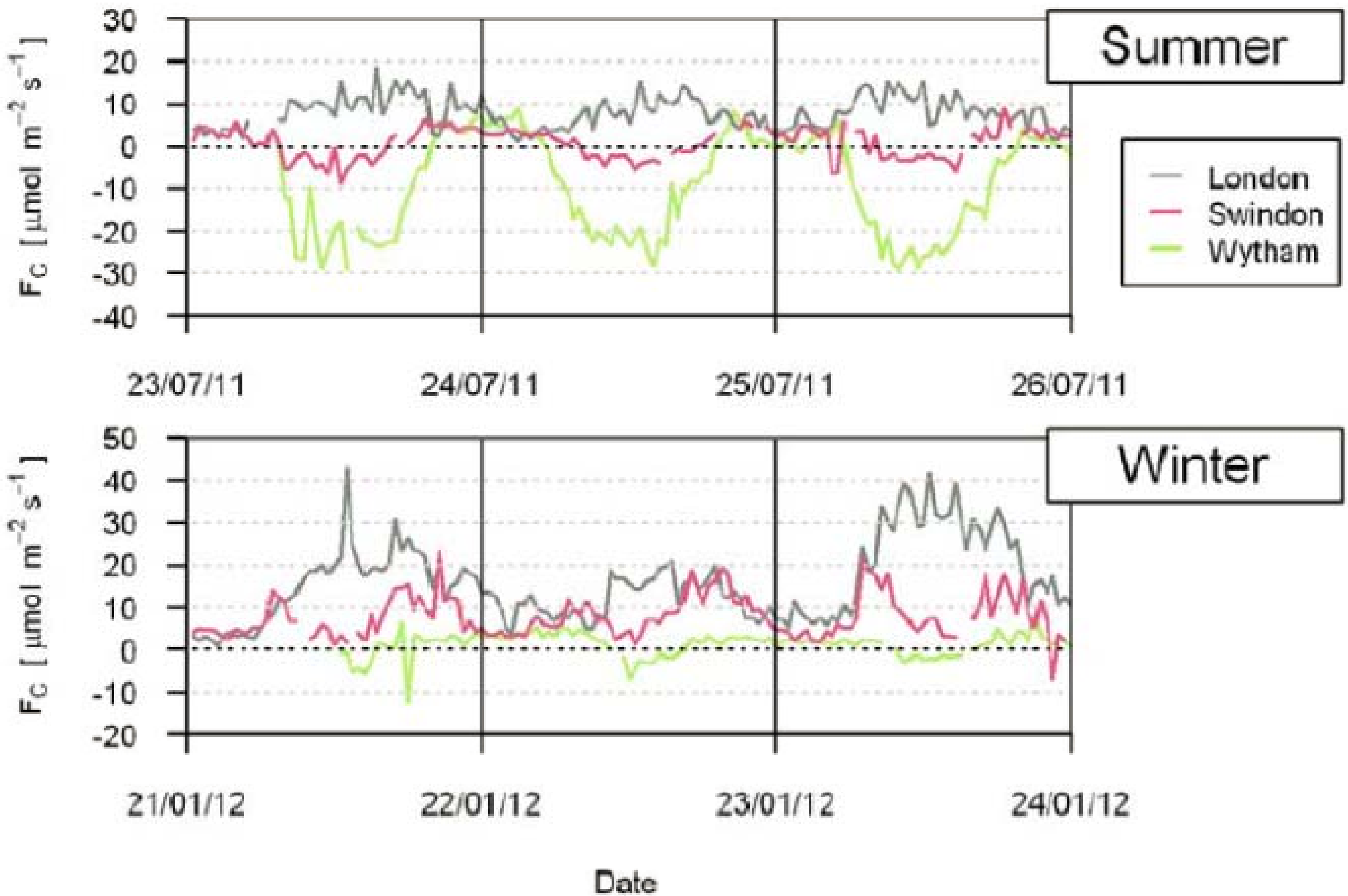


Fig.13 Carbon fluxes for three case study days in summer and winter for the city centre (London), suburban neighbourhood (Swindon) and woodland (Wytham) (*Kotthaus et al., 2012*).

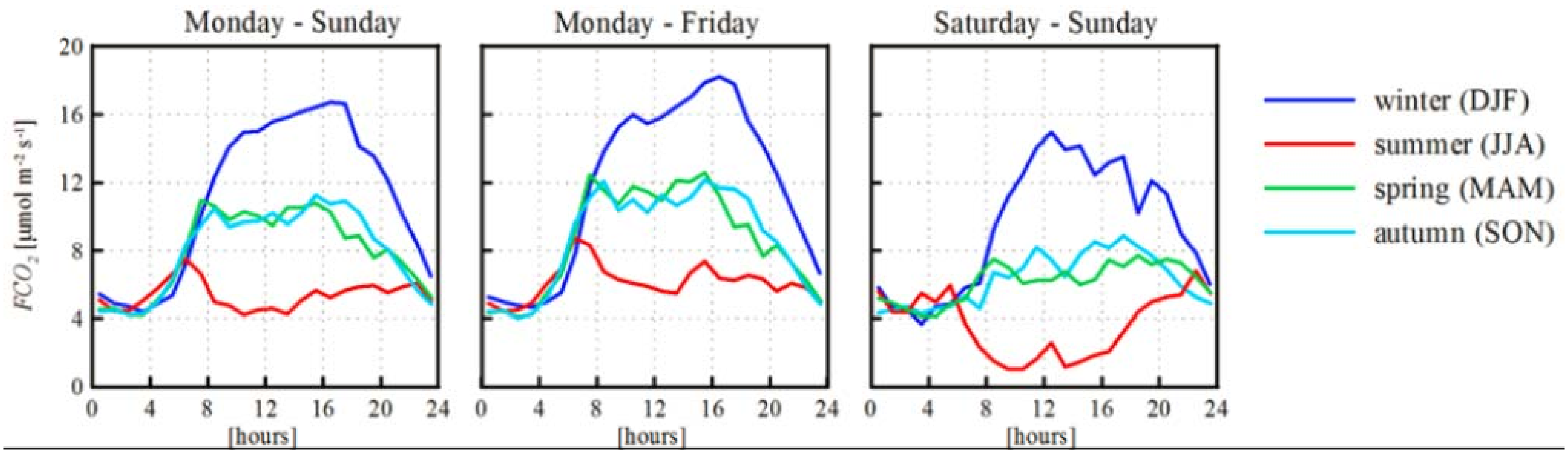


Fig.14 Mean diurnal course of FCO_2 in seasons at Lipowa site calculated separately for full weeks, weekdays and weekends for the period July 2006 to May 2011 (*Fortuniak et al., 2012*).

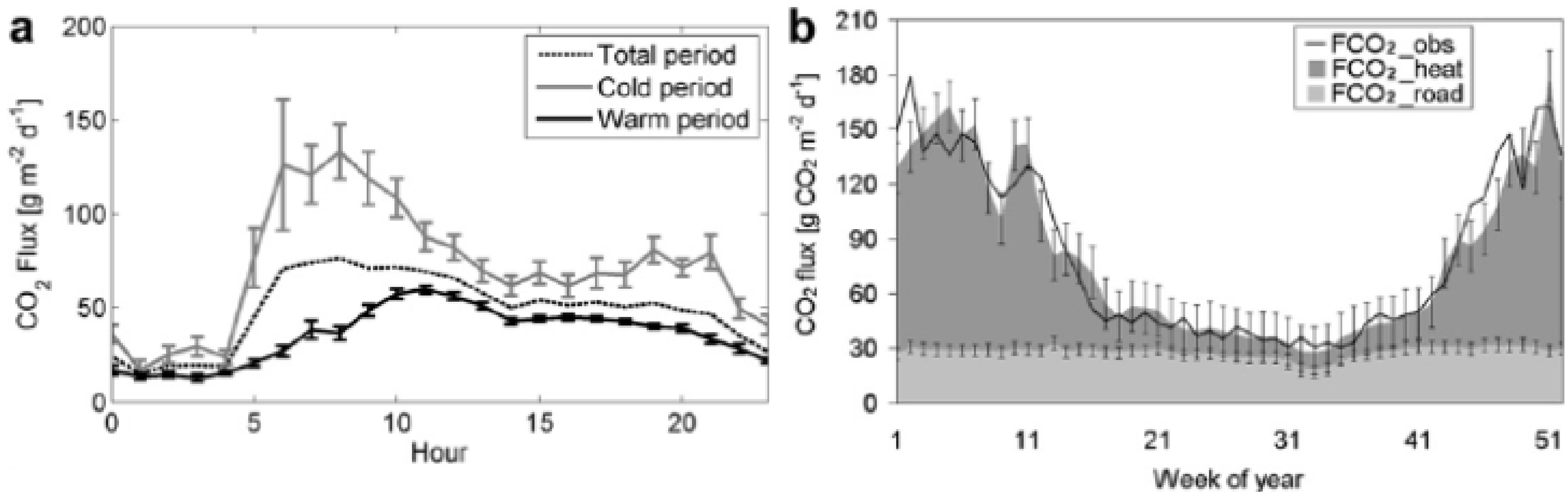


Fig.15 (a) Daily patterns of CO_2 observed hourly fluxes, measured at Florence, Italy during short-term study period in 2011 and (b) weekly CO_2 fluxes related to road traffic (FCO_2_road, grey area), domestic heating (FCO_2_heat, dark grey area) and to observations (FCO_2_obs, black line) (*Gioli et al., 2012*).

4.1 CO_2 flux measurment

- Urban is a carbon source.
- The quality of surface or the land cover affect carbon exchange between urban surface and the atmosphere.
- Traffic and domestic heating are two main anthropogenic activities which decide CO_2 flux.
- The diurnal dynamic of CO_2 Flux is coursed by traffic and vegetation.
- The seasonal dynamic of CO_2 Flux is coursed by vegetation and domestic heating.

4.2 CH_4 flux measurement

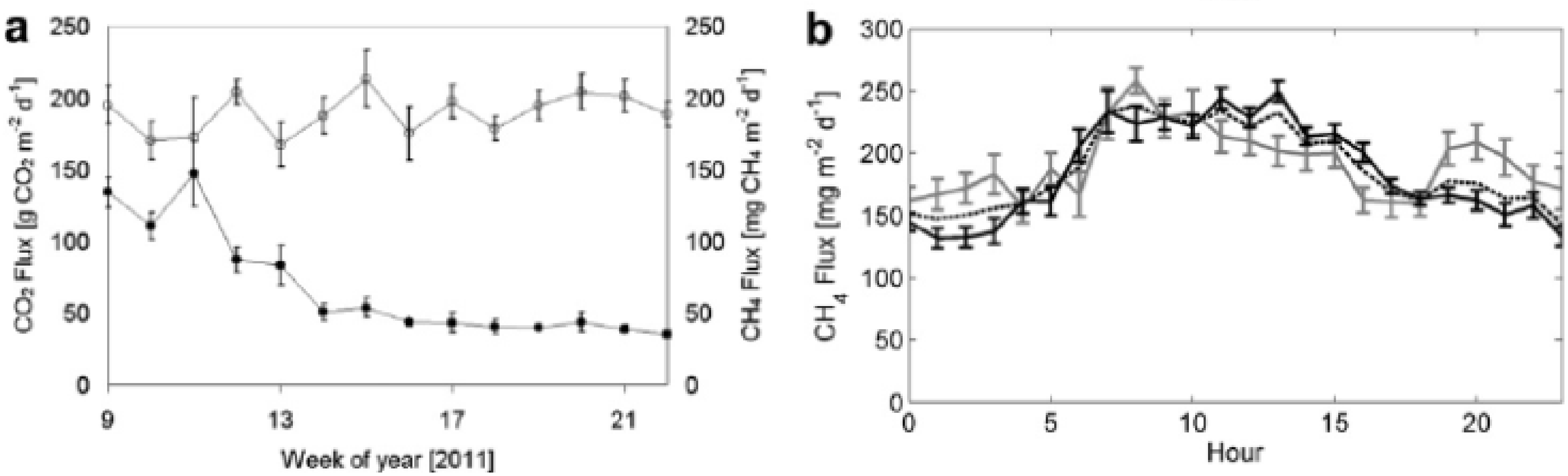


Fig.16 (a) weekly averages of CO_2 (black circles, left axis) and CH_4 (empty circles, right axis) fluxes measured at Florence, Italy during short-term study period in 2011. (b) Daily patterns of CH_4 observed hourly fluxes, measured Florence, Italy during short-term study period in 2011 (*Gioli et al., 2012*).

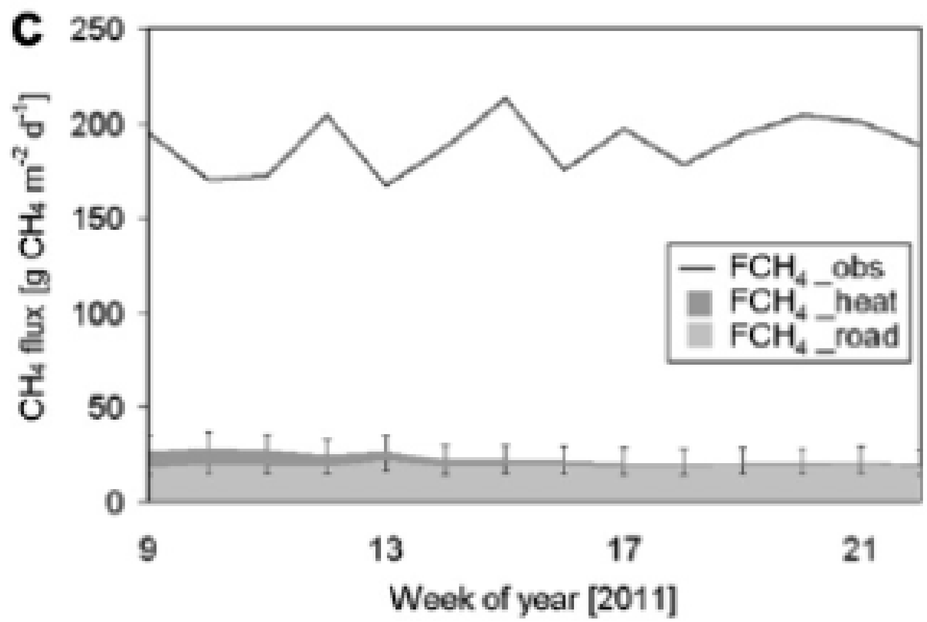


Fig.17 Weekly CH_4 fluxes related to road traffic (FCH_4_road (c), grey area), domestic heating (FCH_4_heat (c), dark grey area), and to observations (FCH_4_obs (c), black line) at Florence, Italy (*Gioli et al., 2012*).

4.2 CH_4 flux measurement

- At Vancouver-Sun set, Canada, daily average CH_4 emission was about $17 nmol m^{-2} s^{-1}$. And CH_4 emission reached the peak at daytime, the maximum value was about $24 nmol m^{-2} s^{-1}$. It decreases in nighttime. The minimum value was about $9 nmol m^{-2} s^{-1}$.

4.2 CH4 flux measurement

- The urban is the CH_4 source.
- The CH_4 emission can be attributed to incomplete combustion, such as traffic, space heating/natural gas. And the attribution of traffic to CH_4 emission was larger than that of domestic heating.

5. Summary

- Investigation of land cover around site is important for discussing results.
- The high quality of data is decided by QA/QC or pre- and post-processing.
- The assistant measurements is important for getting accurate results.

Thank you!