P1.4 FIRST RESULTS FROM BUBBLE II:
PARTITIONING OF TURBULENT HEAT FLUXES OVER URBAN SURFACES

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1. INTRODUCTION

In the framework of the Basel Urban Boundary Layer Experiment (BUBBLE) flux measurements are carried out in the city of Basel (Switzerland) over one year to increase the understanding of exchange processes over urban surfaces. Details of the project can be found in Rotach (2002, same conference). The measurements will last until July 2002 with a continuously operated flux measurement network.

2. INSTRUMENTATION

This contribution focuses on two dense urban canopies at *Basel-Spalenring* and *Basel-Sperrstrasse* (Tab. 1). Both sites are equipped with a micrometeorological tower, each including a profile of six ultrasonic anemometer-thermometers and one level coupled with a fast hygrometer. The measurements of interest for this presentation are carried out at approximately two times the building height, where also full radiation component measurements are installed (Tab. 2). The street canyon at Basel-Sperrstrasse contains no vegetation, where at Basel-Spalenring alley trees are along the street and in the backyard is sparse vegetation too.

Tab. 1: Instrumentation.

Site	**Basel-Spalenring**	**Basel-Sperrstrasse**
WGS-84	07°E 34' 34.6" 47°N 33' 17.6"	07°E 35' 47.8" 47°N 33' 57.2"
Height a.s.l.	278m	255m
Net radiation *Rn*	2 Pyranometer Kipp & Zonen CM11 2 Pyrgeometer Eppley PIR / WRC	1 Net Radiometer Kipp & Zonen CNR1
Sensible heat flux *H*	Ultrasonic anemometer METEK USA-1 40 / 20Hz	Ultrasonic anemometer Gill HS 100 / 20Hz
Latent heat flux *LE*	Fast hygrometer Campbell KH2O	Fast hygrometer Campbell KH2O

Tab. 2: Measurement heights above street level.

	Basel-Spalenring	**Basel-Sperrstrasse**
Rn	32.9 m (z/h=1.8)	31.5 m (z/h=2.3)
H and *LE*	29.9 m (z/h=1.7) 34.0 m (z/h=1.9) [(1)]	31.7 m (z/h=2.3)

[(1)] for measurements prior to September 2001

Results from the first three months of the experiment (Dec 2001 to Feb 2002) and selected data from preceding measurements during 2001 at Basel-

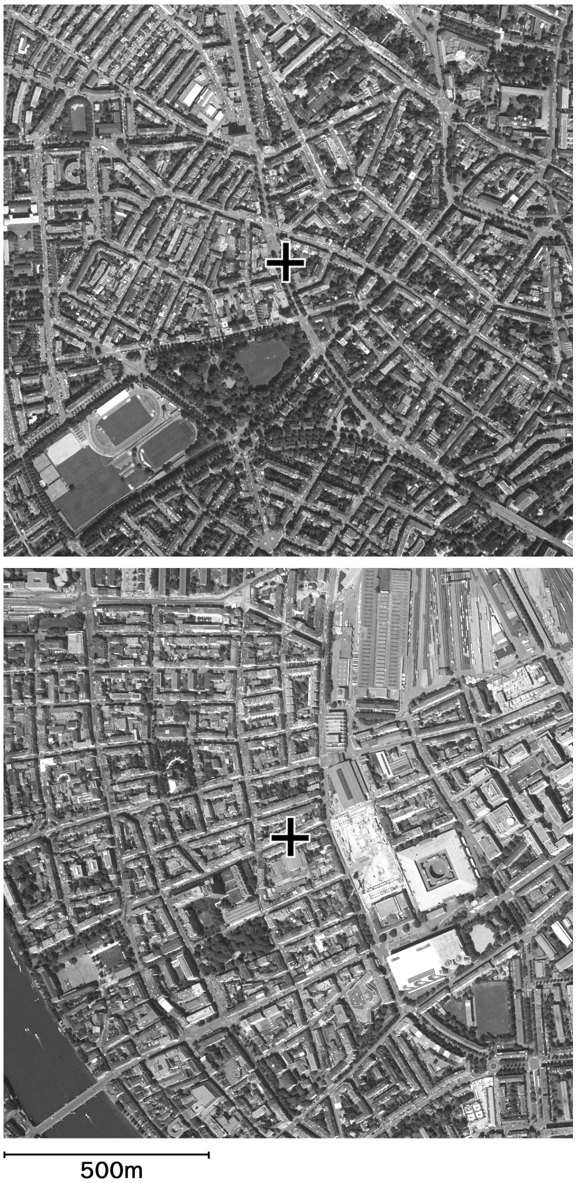

Fig. 1: Aerial view of the two main urban sites during BUBBLE: Basel-Spalenring (top) and Basel-Sperrstrasse (bottom). The crosses refer to the location of the micrometeorological towers. Air photos: © Swiss Fed. Office of Topography, Wabern, 213NE268-4097 / 213NE268-4094.

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Spalenring are presented. Fluxes are calculated from block averages over one hour. Sensible heat flux *H* and latent heat flux *LE* are directly derived from sonic and humidity fluctuation measurements, respectively. The storage heat flux *G* was determined as residual term, and additionally, the rate of change of sensible heat storage of the air column between the surface and the measurement level was taken into account (Thom, 1975). The following sign convention is used: all fluxes directed away from the surface are negative, all fluxes towards the surface are positive. All calculated fluxes are oriented strictly vertical.

3. FIRST RESULTS

The diurnal course of energy balance components at both urban sites is illustrated for a wintertime clear-sky day in Fig. 2. That day is characterized by an extraordinary high storage heat flux with a *G*/*Rn* ratio up to -0.6 during daytime, corresponding to the highest values reported from cities (Oke et al., 1999). These high *G* values are associated with wintertime clear-sky conditions and are not found during overcast days, where usually |*H*| > |*G*|. Note the small latent heat flux with a ratio *LE*/*Rn* around -0.1. In summer clear-sky situations (Fig. 4, left), H and G are more or less equal, and still small *LE* values are observed.

A mean diurnal course based on hourly averages of 80 wintertime days with both, clear-sky and overcast situations, is shown in Fig. 4 and Tab. 3. Data with absolute values of |*Rn*| < 35 W m^{-2} are excluded. Daytime-situation ratios for *H*/*Rn* range between -0.5 and –0.6 and are slightly higher than observed in other studies over urban surfaces. However, *LE* is very small with *LE*/*Rn* around -0.1 and *G*/*Rn*, between -0.2 and -0.4. *LE* is lower than in most studies done before (e.g. Grimmond and Oke, 1995).

The winter nighttime situations are characterized by radiative loss which is counterbalanced by even higher *G*-values (*G*/*Rn* ~ -1.1 to 1.2). The turbulent fluxes stay slightly negative i.e. away from the surface (*LE*/*Rn* ~ 0.03, *H*/*Rn* 0.1 to 0.2). This partitioning of the nocturnal wintertime energy balance is probably influenced by anthropogenic emissions and heating. Due to lower absolute values of *Rn*, the anthropogenic influence is more pronounced at nighttime.

4. REFERENCES

Project website: www.mcrlab.unibas.ch/projects/BUBBLE/

Grimmond, C. S. B. and T. R. Oke, 1995: Comparison of heat fluxes from summertime observations in the suburbs of four north American cities. *J. Appl. Meteor.*, **34**, p. 873-889

Oke, T. R., Spronken-Smith, R. A., Jáuregui, E. and C. S. B. Grimmond, 1999: The energy balance of central Mexico City during the dry season. *Atmos. Environ.*, **33**, p. 3919-3930.

Rotach, M. W., 2002: Overview on the Basel Urban Boundary Layer Experiment—BUBBLE. *This conference*, paper 3.6.

Thom, A. S., 1975: Momentum, mass and heat exchange. In: J. L. Monteith (Ed.), Vegetation and atmosphere, Vol 1., London, Academic Press.

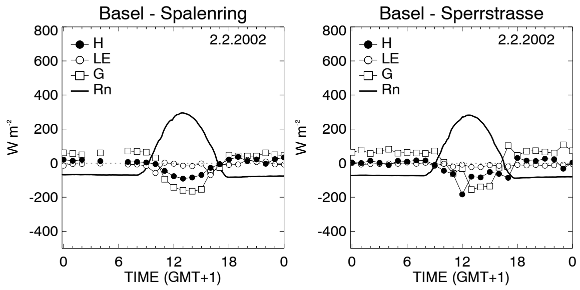

Fig. 2: Diurnal course of a selected wintertime clear sky day (Feb 2, 2002) at both sites Basel-Spalenring (left) and Basel-Sperrstrasse (right) based on hourly fluxes.

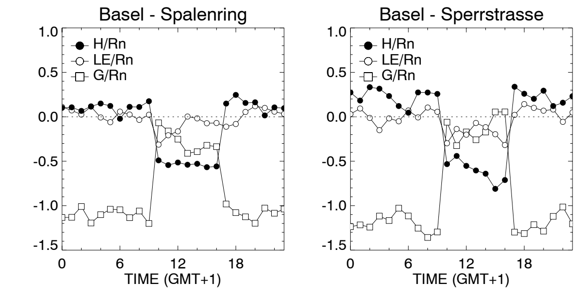

Fig. 3: Average diurnal course of the energy balance components normalized by the available net radiation *Rn* for Basel-Spalenring (left) and Basel-Sperrstrasse (right) during the wintertime period from Dec 1, 2001 to Feb 18, 2002 including all sky conditions.

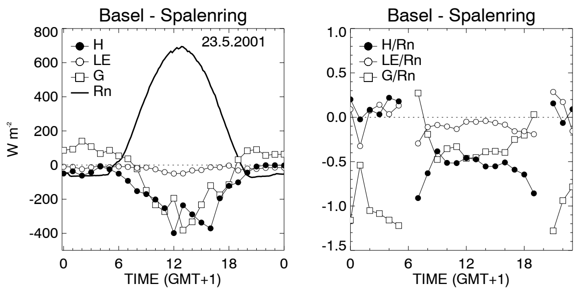

Fig 4: Diurnal course of a selected early summer clear-sky day (May 23, 2001) at Basel-Spalenring (left). Average diurnal course for a summertime period between June 29 and July 12 2001 similar to Fig. 3 (right).

Tab. 3: Averages of energy balance components normalized by *Rn* for the wintertime period Dec 1, 2001 to Feb 18.

			Basel-Spalenring	Basel-Sperrstrasse
Winter	*Day*	*G*/*Rn*	-0.31	-0.17
		H/*Rn*	-0.54	-0.61
		LE/*Rn*	-0.09	-0.14
	Night	*G*/*Rn*	-1.08	-1.20
		H/*Rn*	+0.11	+0.23
		LE/*Rn*	+0.03	+0.03