**9.5** MULTI-POINT MEASUREMENTS OF HEAT AND MOMENTUM FLUXES ABOVE ROOF LEVEL IN AN URBAN AREA

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## 1. INTRODUCTION

The urban boundary layer is a special case of boundary layers with large size roughness elements. Such boundary layers pose both an experimental and theoretical challenge. In this paper, we chose to focus our attention on the heat flux. Our choice was motivated by the fact that momentum fluxes, velocity and temperature fluctuations over urban boundary layers have been studied rather extensively (cf. Roth 2000). Furthermore, the heat flux probably constitutes the most important factor in establishing the often-discussed urban heat island effect.

Two main streams for heat flux parameterization over heterogeneous terrain are frequently encountered in the literature (cf. Voogt 2000), the so-called macroscopic, or bulk surface approach, and the microscale surface variation approach. Both approaches aim to deal with the temperature and heat flux heterogeneity of individual roughness elements. Due to the complexity of the microscopic problem and in the absence of a good theory, this type of parameterization utilizes similarity theory on microscopic scales explicitly (Masson 2000) and in some cases implicitly (Voogt 2000).

The question whether the bulk or microscopic approach is preferable is still debated. In fact, both approaches spatially average over a plane. The surface bulk parameterization averages the temperatures, whereas the microscopic parmetrization averages heat fluxes. Voogt (2000) argue that the bulk surface parameterization is more robust as compared to the microscopic (with implicitly assumed local similarity) approach. Furthermore, they demonstrate problems with the implicit assumption of local similarity, accompanied by a two-type roughness population, each having its own temperature. In light of their findings, we choose to experimentally test the existence of local similarity.

## 2. EXPERIMENTAL AND RESULTS

We present results from a single day and night of turbulent fluxes obtained from field measurements on two roofs. These roofs are located deep within an urban fetch. Our aim in this experiment was to study qualitatively the existence of similarity on a local scale, thus testing the ability to properly quantify the heat flux with a microscopic approach using the assumption of local similarity. Since we were a priori skeptical, we hoped further to establish the existence of a self preserving heat flux layer above a single roof top, which is a weaker assumption

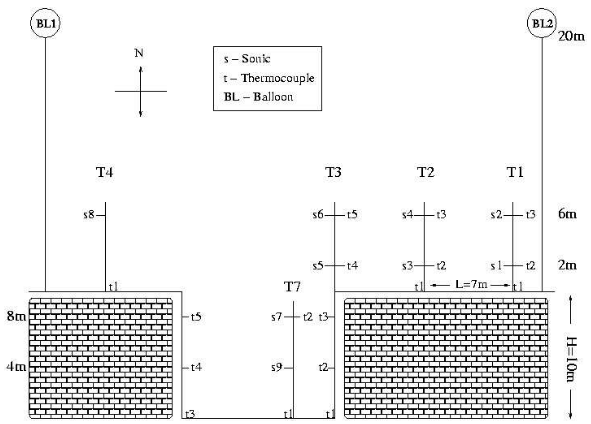


Fig. 1: measurement setup

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Figure 1 shows turbulence measurement devices that were situated on a single roof. This roof height was roughly 10 meters above street level. For reference proposes, another identical anemometer was mounted on an adjacent roof upwind at the same height level as the high downwind anemometers. A detailed description of the experiment and the anemometers is given by Fattal (2002).

We focus on the interesting experimental relations. We consider first the skewness and flatness. These quantities of the temperature and vertical velocity fluctuations are not presented here for sake of brevity, but are consistent with a nearly Gaussian distribution of these fluctuations.

During the day, the variance of the temperature, the vertical velocity fluctuations, and the heat flux show a pronounced internal boundary layer (IBL) type of behavior. This can clearly be seen from the bottom panel of fig. 2. The top panel of fig. 2 further reveals that the correlation coefficient of the temperature and vertical velocity fluctuations is very close to 0.5. Yet a 30% variation between them preserves the IBL behavior. We note in passing, that the correlation coefficient of the momentum flux (not shown here) is nearly 0.25 with a similar scatter and without any pronounced spatial structure. Both correlation coefficients exhibit minor diurnal change but are more scattered during the night.

During nighttime, the heat flux is consistent with similarity theory.

**3. CONCLUSIONS**

The hypothesis of local constant flux layers over an individual roof-top does not agree well with our measurements during daytime. We conjecture that the agreement found during the nighttime is due to light wind conditions. During the day an IBL structure is very pronounced for the heat flux, the temperature fluctuations, and the vertical velocity fluctuation. Such a structure for the momentum flux is not observed (Gavze 2002).

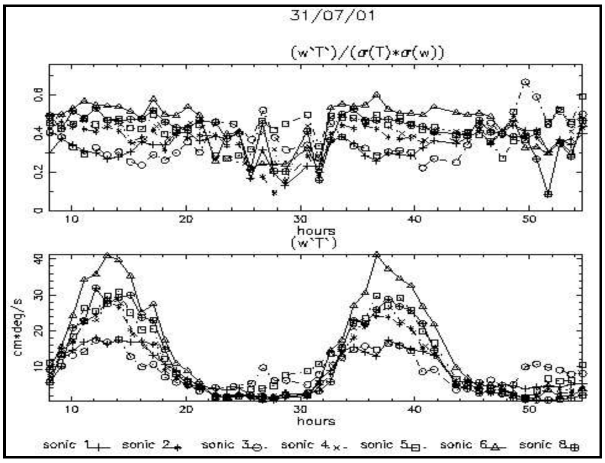


Fig. 2 Heat flux and T-W correlation

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