p1.4 TURBULENCE PROPERTIES OF THE STREET-ROOF SCALE WITHIN THE URBAN ROUGHNESS SUB-LAYER

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1. INTRODUCTION

Air flow in the urban roughness sublayer is much more complex than its counterpart in the atmospheric surface layer. This is due to the much larger size of the roughness elements and the unevenly distributed heat sources. Thus, the use of surface layer similarity theory (SLST) for the parameterization of the mean flow is limited. Recent evidence from wind tunnel experiments indicates that the basic assumption of SLST, i.e., the constancy of momentum fluxes in the vicinity of the roughness elements, is not fulfilled, Kastner-Klein (2001), Ashie (2000). In both experiments a sharp maximum of the momentum flux was observed above the roughness elements. Kastner-Klein (2001) suggested that in spite of the inconstancy of the momentum flux, a logarithmic velocity law may be reproduced with u_* obtained from a single reference point. The aim of this paper is to investigate the momentum flux and the wind profile above the roof level in a real urban environment.

2. EXPERIMENTAL SETUP

The experimental setup is described in detail in Fattal (2002). A schematic description of the distribution of the measuring instruments is shown in Fig. 1. The data, discussed in this paper, were collected above the roofs from poles T1, T2,T3,T4, and from the tethered balloons. Measurements on poles T1,T2 and T3 were taken at two heights, 2m and 6m above the roof, i.e., z/h=1.2, 1.6. On T4 measurements were taken only at 6m. The balloons height was 20 m above the roof level, i.e., at z/h=3.

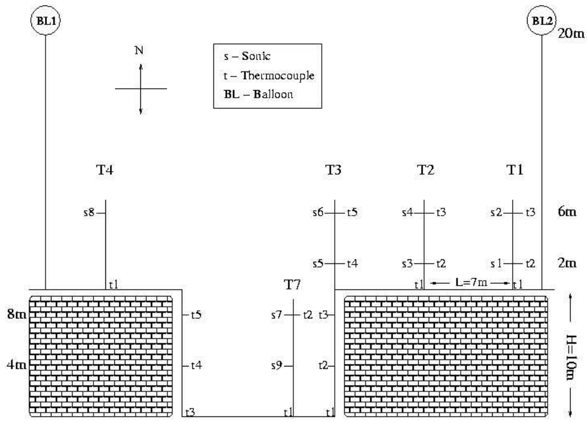

Fig. 1 The measurement setup

3. RESULTS

The measurements were taken during four days in summer 2001. Here we present hourly averages of two days: 31/7 - 1/8/2001. During the day the wind regime was controlled by the sea breeze, which came mainly from the west, i.e., perpendicular to the street between the two buildings. At night the wind changed direction and came mainly from the south-east. Fig. 2 presents hourly averages of the momentum fluxes parallel and perpendicular to the mean wind. The numbering of the sonic anemometers corresponds to the numbering in Fig. 1. During the day, the flux component parallel to the mean flow exhibits clear dependence on height. In fact, the fluxes at z/h=1.6 are 2-4 times larger than those at z/h=1.2. The horizontal pattern of the flux is more complex. At night, when the wind speed diminishes, all

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fluxes collapse to almost the same value, thus preserving similarity properties. The flux component perpendicular to the flow exhibits a more complex behavior. All upper stations, except station 6, which is located above the street, exhibit positive fluxes during the morning. In the afternoon the fluxes change to negative. At night most of the stations show zero fluxes. One should note that in an open area this flux component should vanish. For a discussion on the heat fluxes, see Pistinner (2002).

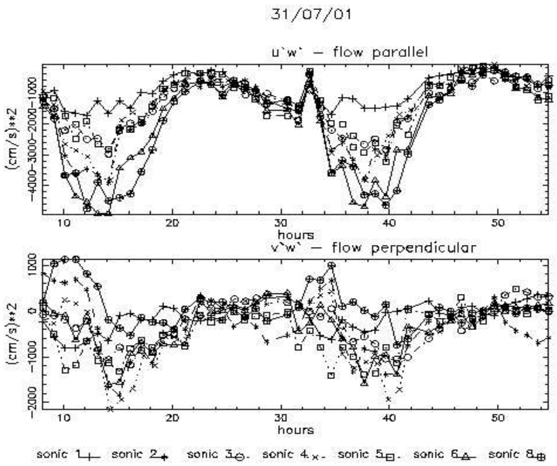

Fig 2. momentum fluxes

4. ANALYSIS

In spite of the fluxes being height dependent, it is worthwhile determining whether the wind velocity obeys a logarithmic law, as in the wind tunnel experiments. To this end we define a height dependent 'effective' friction velocity:

$$u_*^{eff}(z) = \kappa \tilde{u}(z) / \log(\frac{z - z_d}{z_0})$$

where the following values were used:

z_d=0.7h =7m, z_0=0.1h=1m.

$\tilde{u}(z)$ is the horizontal average of the measured velocity. As mentioned above, measurements were conducted at z=2m, 6m and 20m above roof level. Fig. 3 shows the effective friction velocity and the measured horizontal average of u_*. During daytime u_* at z/h=1.6 is about 30% larger than at z/h=1.2. The deviations of u_*^{eff}, on the other hand, amount to about 10% - 15% during the first day. The larger deviations observed at 20m in the second day may be attributed to the lack of data. At night the tendency is reversed. We may, therefore, speculate that a logarithmic profile serves as a fairly good approximation during daytime, at least up to z/h=3. We should mention that no stability corrections were taken into account.

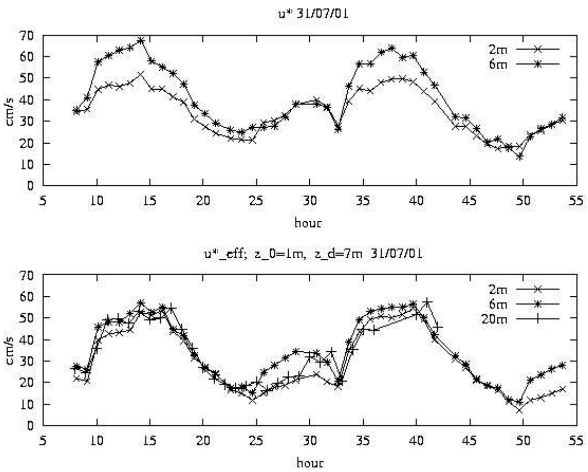

Fig 3. friction and “effective” friction velocities

5. REFERENCES

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