j1.14 COMPARISON BETWEEN THE WIND AND TEMPERATURE FIELDS WITHIN THE ROUGHNESS SUB-LAYER AND AN OPEN AREA

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1. INTRODUCTION

The urban environment is one of the most studied fields in the atmospheric boundary layer (Roth 2000). Yet, due to its special complexities, such as the large size of roughness elements and the local spatial variability in wind field, it is still treated mainly on a semi-empirical basis. As a result, there is still a great demand for directly measured, high quality data both in the urban area and as a comparison to open area.

We present results of wind, temperature and turbulent fluxes from a field experiment that included measurement on two roofs and in a street between them, deep within an urban fetch of a coastal city in Israel during the summer. The wind conditions that prevail are those of the breeze cycle. The city is east of the seashore, giving rise to a western sea breeze during daytime.

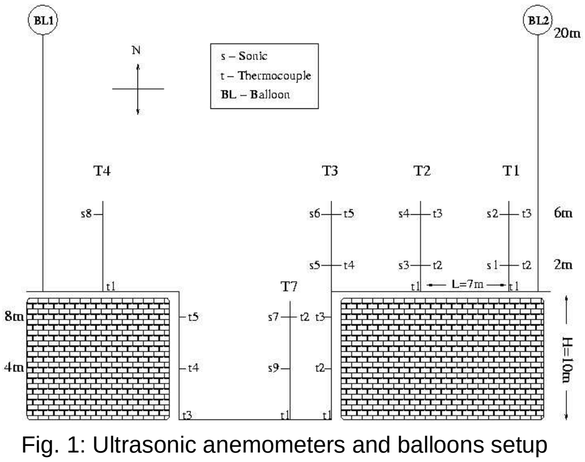

Fig. 1: Ultrasonic anemometers and balloons setup

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2. EXPERIMENTAL AND RESULTS

Wind, temperature and turbulence measurements were conducted on two roofs and in a street between them from July 29 to August 2, 2001. Three pairs of identical 17cm path length, 10Hz sampling rate, ultrasonic anemometers (USA-1 Metek Gmbh) were mounted at heights of 2 and 6 meters above the main rooftop (Fig. 1: poles T1, T2, T3). The pairs were seven meters apart from each other, covering a third of the roof length. All anemometers were collected on the same DSP card to ensure synchronization. The roof height was roughly 10 meters above street level, so that in terms of normalized heights the measurements were performed at $z/h=1.2$ and $z/h=1.6$. Another anemometer was mounted on an adjacent roof upwind at the same height above the roof level as the high downwind anemometers, i.e., at $z/h=1.6$. Two more anemometers were mounted in the street (pole T7) at heights 4 and 8 meters above street level, i.e., at $z/h=0.4$ and $z/h=0.8$. In addition, two tethered balloons were positioned roughly 50 meters apart (see Fig. 1) to measure the wind direction and speed continuously. The height of these tethered balloons was varied between 20 and 40 meters above roof level, i.e., at $z/h>3$. One reference anemometer was positioned in an open area outside the city, 12 meters above ground level. Measurements were continuously logged for a period of four days.

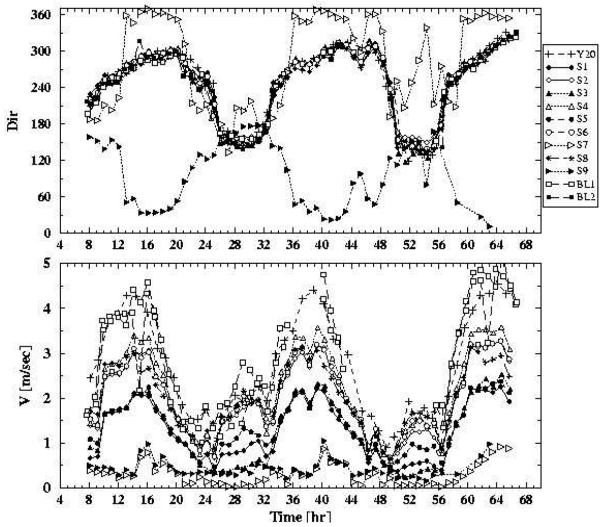

Fig. 2 Hourly averages of the wind speed (lower figure) and direction (upper) vs. time (hours). For sonics(S#) and balloons (BL#) Refer to Fig. 1. Y20 - open area measurement.

The main findings were:

1. The *wind direction* is almost identical in all sites including the open area station, with the exception of the anemometers below roof level. There the wind direction follows the general direction of the street.
2. *Wind speeds* can be divided into four groups. The groups are as follows (from low to high speeds): street (2 stations), 2 meters above the roof (3 stations) and 6 meters above the roof (6 stations). The fourth group consists of the two balloons and the station in the open area.
3. Wind speed 6 meters above roof level is 50%-70% of the speed measured in the open area.
4. Differences of up to 1 m/sec were observed in the wind speed measured by the two balloons. Temperatures, on the other hand, were almost identical.

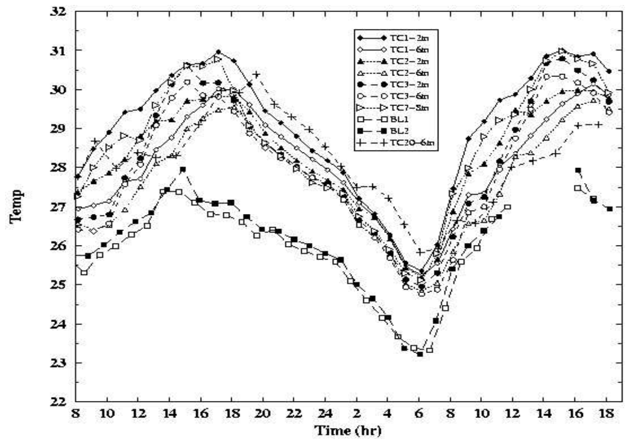

Fig. 3 Hourly averages of air temperatures vs. time (hours)

5. During most of the day and night(!) the *stratification* above the roof was unstable. Temperature differences between the balloon level and the roof level reached their maximum, of 2-4^{o}C, in the afternoon. The minimum was reached in the morning with less than 1^{o}C difference. Thus, within the experimental error, this temperature difference persisted for about 2 hours only.
6. Surfaces *temperatures* were always higher or equal (within the experimental error) than the air temperatures. Surface temperature minimum values were observed shortly before sunrise. Relative humidity values were 60-80%.

The turbulence properties are discussed in Gavze (2002) and Pistinner (2002).

3. REFERENCES

1. Roth, M. 2000: Review of atmospheric turbulence over cities, Q. J. R. Meteorol. Soc., **126**, pp. 941-990.
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