

USE OF A LOW-TROPOSPHERIC WIND PROFILER WITHIN AN URBAN ENVIRONMENT¹

Dominique Ruffieux, Noemie Tharin, Heinz Berger
MeteoSwiss, Aerological Station, CH-1530 Payerne, Switzerland
Tel. : +41 26 662 6247, Fax. : +41 26 662 6212
Email : dominique.ruffieux@meteoswiss.ch

1. Introduction

Within the European COST715 Action “Meteorology Applied to Urban Air Pollution Problems”, the Swiss “BUBBLE” (Basel UrBan Boundary-Layer Experiment) project was elaborated in order to better understand the urban climate of the city of Basel. A combination of in-situ and ground-based remote sensing systems were operated continuously from July 2001 until end of Summer 2002. These data will be intensively used to run meteorological and chemical models. MeteoSwiss participated at BUBBLE by setting a low-tropospheric wind profiler next to the center of the city.

The wind profiler (Ecklund et al., 1988) is an active ground-based remote sensing system which can be affected by various types of contamination (Wilczak et al, 1995). The setting of this system within the urban domain was the opportunity to demonstrate the potential of such instrument to correctly operate in such an environment. Preliminary analysis of wind speed and direction, vertical motions as well as signal-to-noise ratio are presented for a cloud-free day case.

2. Topographical situation

The 200'000 people city of Basel is located in the Rhine Valley, in the northern part of Switzerland. It is surrounded by the Jura mountains to the South, by the Black Forest in Germany, and by the Vosges Mountains in France (Figure 1). The 1290MHz wind profiler (Ruffieux, 1999) is set next to downtown, within a densely constructed area.

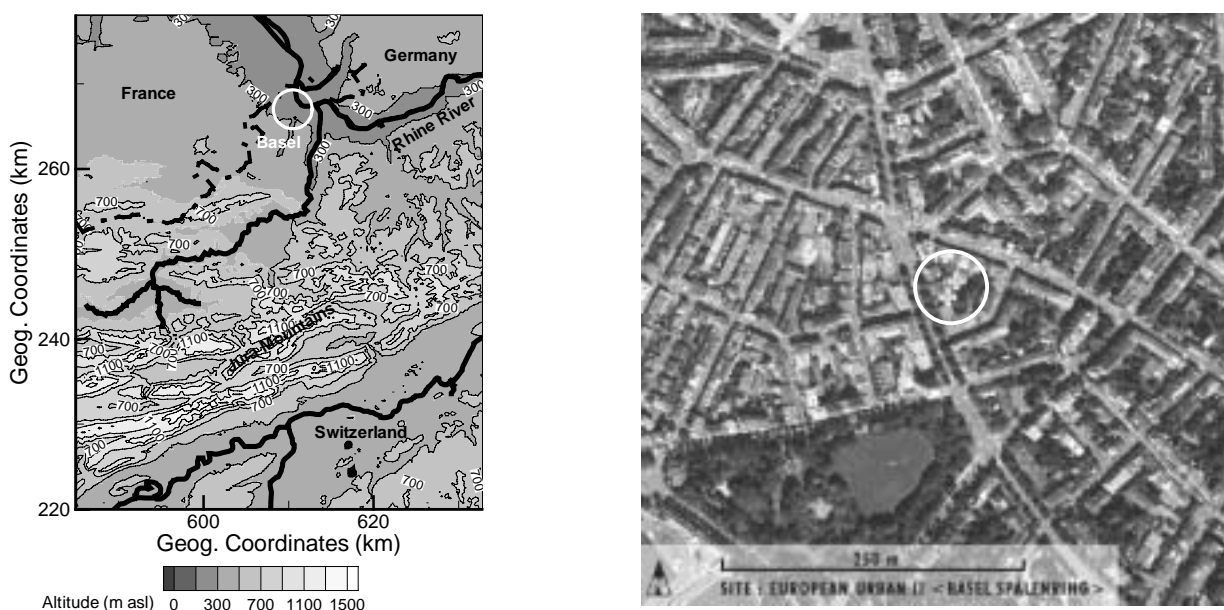


Figure 1. General topographical situation of Basel (left panel) and location of the wind profiler within the urban network (right panel, white circle).

¹ Instruments and Observing Methods TECO-2002, Bratislava (SL), 23-25 September, 2002. WMO Report No.25, WMO/TD-No 1123.

3 Case study

To illustrate the potential of a wind profiler to measure the wind within an urban environment, a sunny Spring day was chosen: 17 May, 2002. The air temperature time series from both downtown and a rural site (a few kilometers apart) is shown on Figure 2. A general urban overheating of 2-3 degrees can be observed this day.

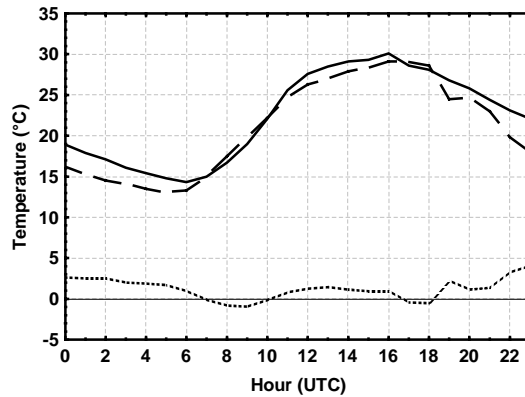


Figure 2. Two-meter temperature time series, 17 May, 2002. The solid line represents downtown (Spalening, at 3 m agl), the dashed line a rural site (Lange Erlen, at 2 m agl), and the dotted line the difference.

The wind profiler 30 minute time series of wind speed and wind direction for the same day (Figure 3) shows the temporal evolution of the flow above Basel. A WSW stable regime can be noticed above 1500 m msl, while a variety of topographically influenced flows are developing below: a nighttime weak SE to S wind is followed, at 13H00 UTC, by a typical thermally forced W flow lasting until the evening. The analysis of the maximum signal-to-noise return is drawn on the same Figure: they are representative of a nocturnal residual layer (A) and of the development of the daytime convective planetary boundary layer (B). The zone (C) corresponds to the period of maximum intensity of SNR and may be related to an urban effect (increased turbulence).

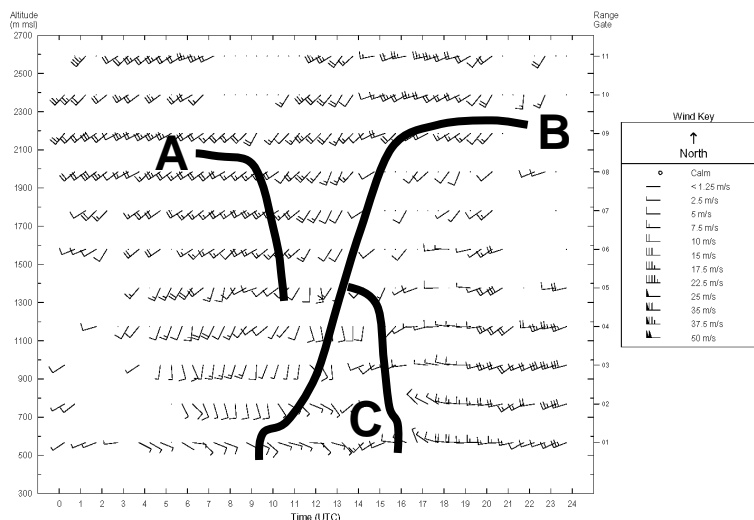


Figure 3. Time series of wind speed and wind direction, 17 May, 2002. The bold solid lines accompanied with letters represent the altitude of maximum signal-to-noise returns and correspond to characteristic heights (see explanation in text).

A re-processing of the raw wind profiler data (Ruffieux et al, 2001) allows to increase the temporal resolution of the consensed wind components. The 10 min. time series of vertical motions for the 300 m agl level and for the same day is shown in Figure 4.

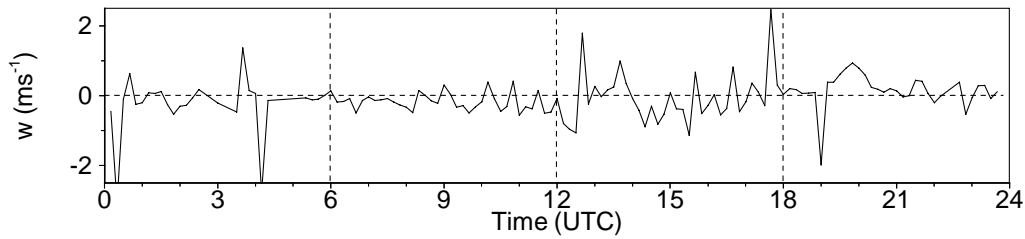


Figure 4. Time series of vertical motions measured at 300 m agl, 17 May, 2002. Consensus time is 10 minutes.

At 300 m agl, the vertical motions vary both in sign and amplitude, independently from speed and direction of the flow. It is interesting to note the significant change between the morning and the afternoon which is characterized by a higher variability.

The day can be divided in four sections with the night time period (00H00 to 06H00), the morning period (06H00-12H00), the afternoon period (12H00-18H00), and the evening period (18H00-24H00). By averaging the vertical motions for these four periods, a mean profile of the w -component can be obtained (Figure 5).

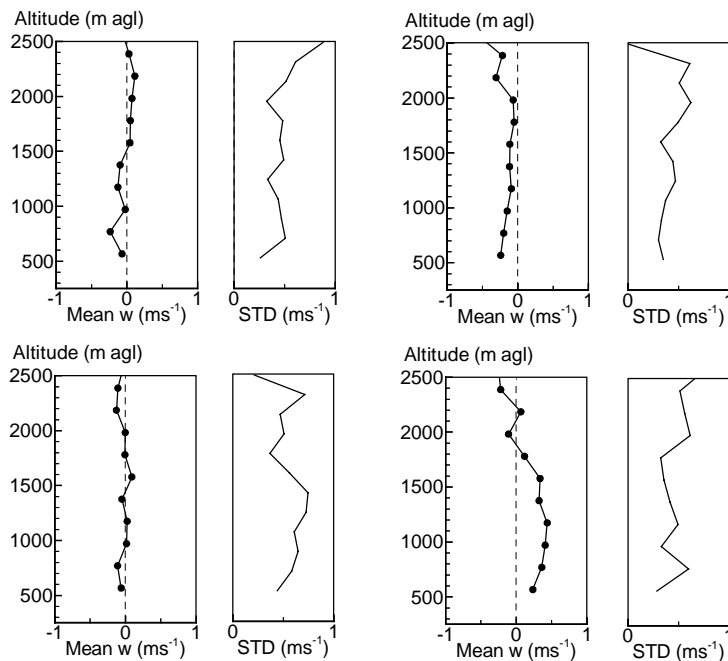


Figure 5. Mean and standard deviation (STD) profiles of vertical motions, 17 May, 2002. Nighttime is shown on the upper left panels, morning time on the upper right panels, afternoon time on the bottom left panels, and evening time on the bottom right panels.

The 2000 m agl limit corresponding to the top of the CBL (see Figure 3) can be detected on the mean profiles of the daytime and evening time of both the means (morning and evening) and the standard deviations (afternoon).

This preliminary analysis based on one clear day of wind profiler measurement showed the potential use of this type of data in order to detect the temporal evolution of the flows and the various layers typical for an urban environment influenced by the topography. The passage from the nighttime easterly regime to the convective westerly flow within the first 1500 m agl is well described by the wind profiler. The analysis of the vertical motions measured during the same case study showed various behavior -in speed (positive and negative) as well as in variability- depending of the period of the day. Further combination of both in-situ and ground-based remote sensing systems (wind profiler and lidars) should permit a good characterization of the heat island of the city of Basel.

5 References

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