SODAR-based Investigation of the Atmospheric Boundary Layer in the Rench Valley during COPS

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1. Introduction

During the COPS-IOP (1 June 2007 to 31 August 2007) SODAR-based measurements of the atmospheric boundary layer (ABL) were conducted in the Renchtal Valley near Oberkirch by the Meteorological Institute, Albert-Ludwigs-University of Freiburg. The Renchtal Valley is NE-SW oriented, located in the western part of the Black Forest. The surrounding mountains reach about 500 m a.g.l. Beside the analysis of the diurnal course of the local wind field the aim was to investigate the impact of complex terrain and the turbulence characteristics to the local atmospheric processes.

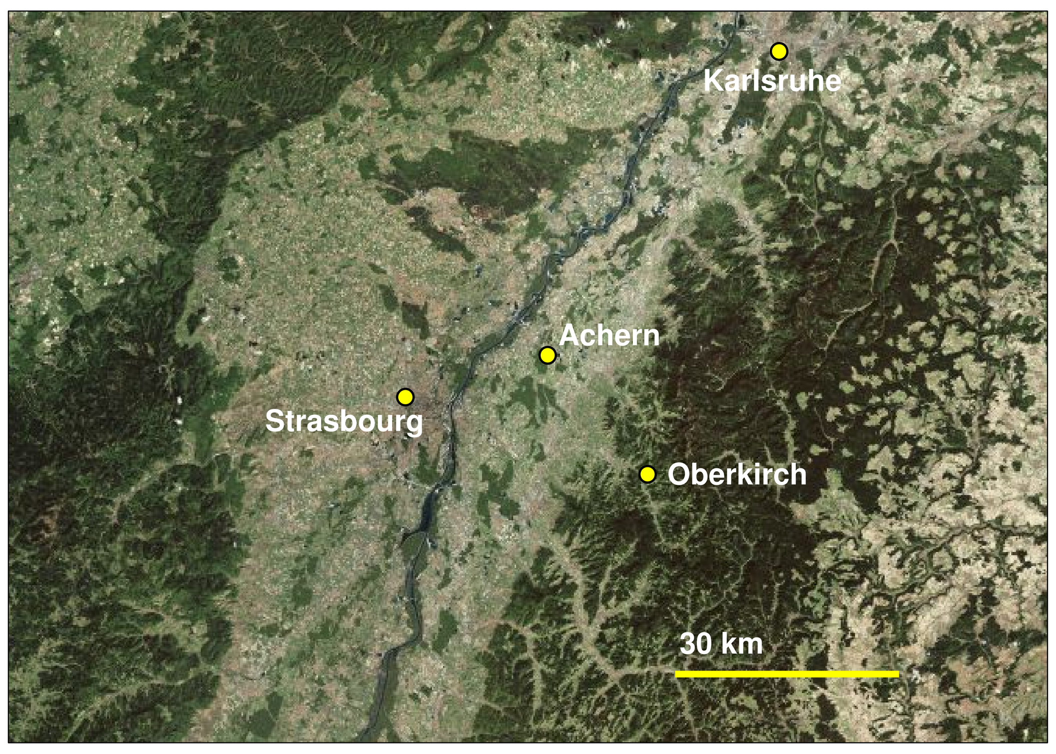

Figure 1: Location of Oberkirch and Achern in the Upper Rhine Valley (source: Google Earth)

2. Methods

A FAS64-SODAR (Scintec) was used for remote measurements of profiles of three-dimensional wind speed, direction and turbulence characteristics in the lower atmosphere. In this study the FAS64 provided the following data in the range from 30 m to 700 m a.g.l. in form of vertical layer related mean values over 10 minutes:

- longitudinal wind vector component (u),
- lateral wind vector component (v),
- vertical wind vector component (w),
- horizontal wind speed (U),
- wind direction (dd),
- standard deviations of all wind vector components (σ_i; i=u,v,w) and standard deviation of the wind direction (σ_{dd}).

An ultrasonic anenometer (METEK USA-1) was installed in addition to verify the SODAR-processed wind parameters in the lowest layers. For several days it was possible to use wind data of the radiosondes starting at Supersite Achern (approximately 25 km north-east of Oberkirch, see Figure 1) for comparison with the SODAR-data.

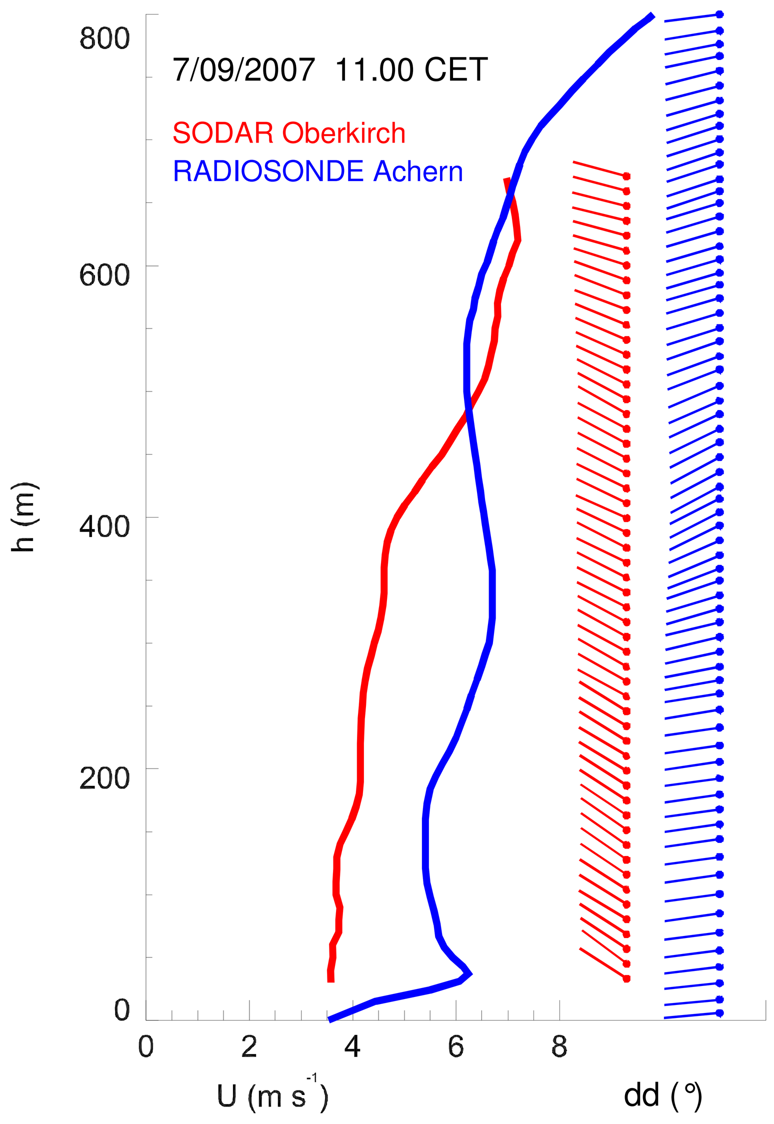

Figure 2: Comparison of horizontal wind speed U and wind direction dd between SODAR measurements at the Renchtal Valley and radiosonde soundings at Achern on 9 July 2007, 11.00 CET. The points on the wind barbs indicate the direction on where the wind flows.

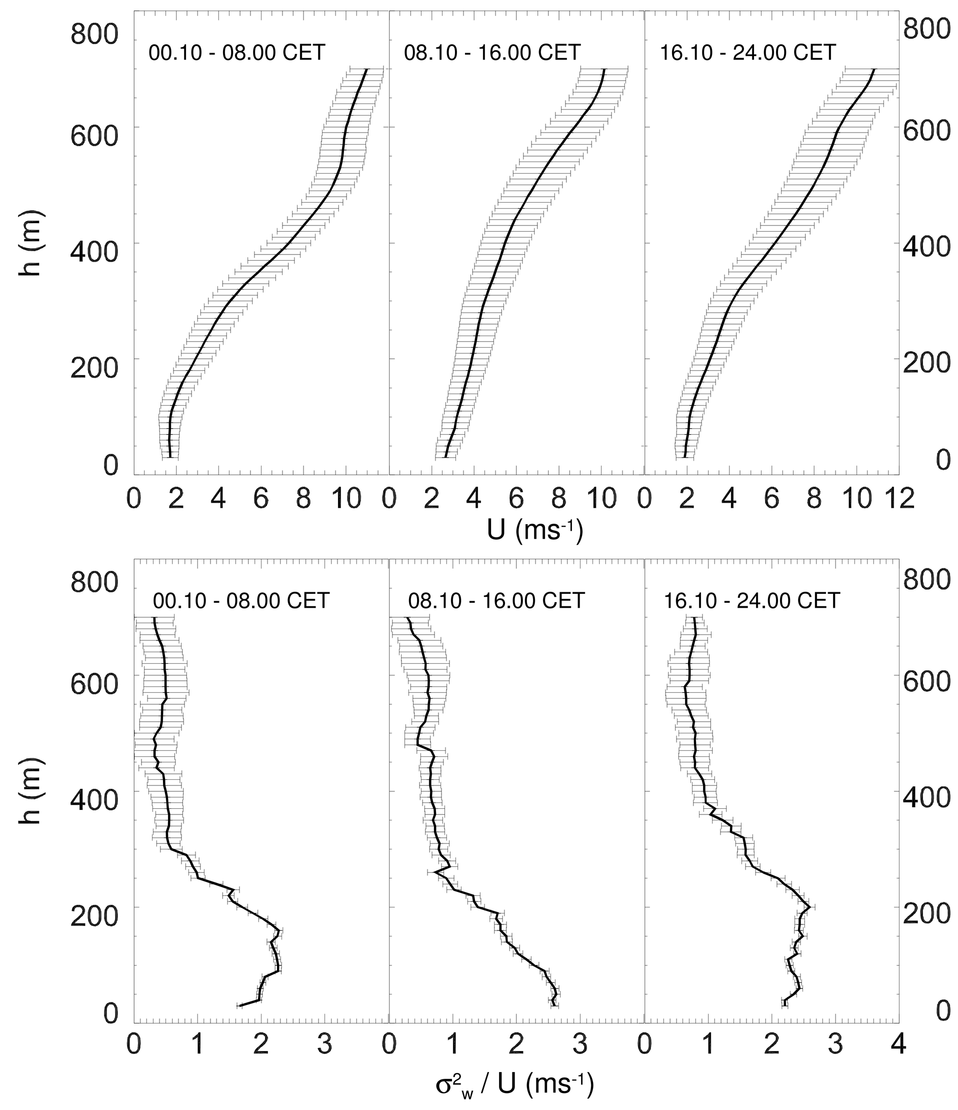

Figure 3: Composite vertical profiles of mean wind speed U and σ_w^2/U, means for 0.10-8.00, 8.10-16.00 and 16.10-24.00 for July 2007. Standard deviation of each sample at each level indicated by error bars.

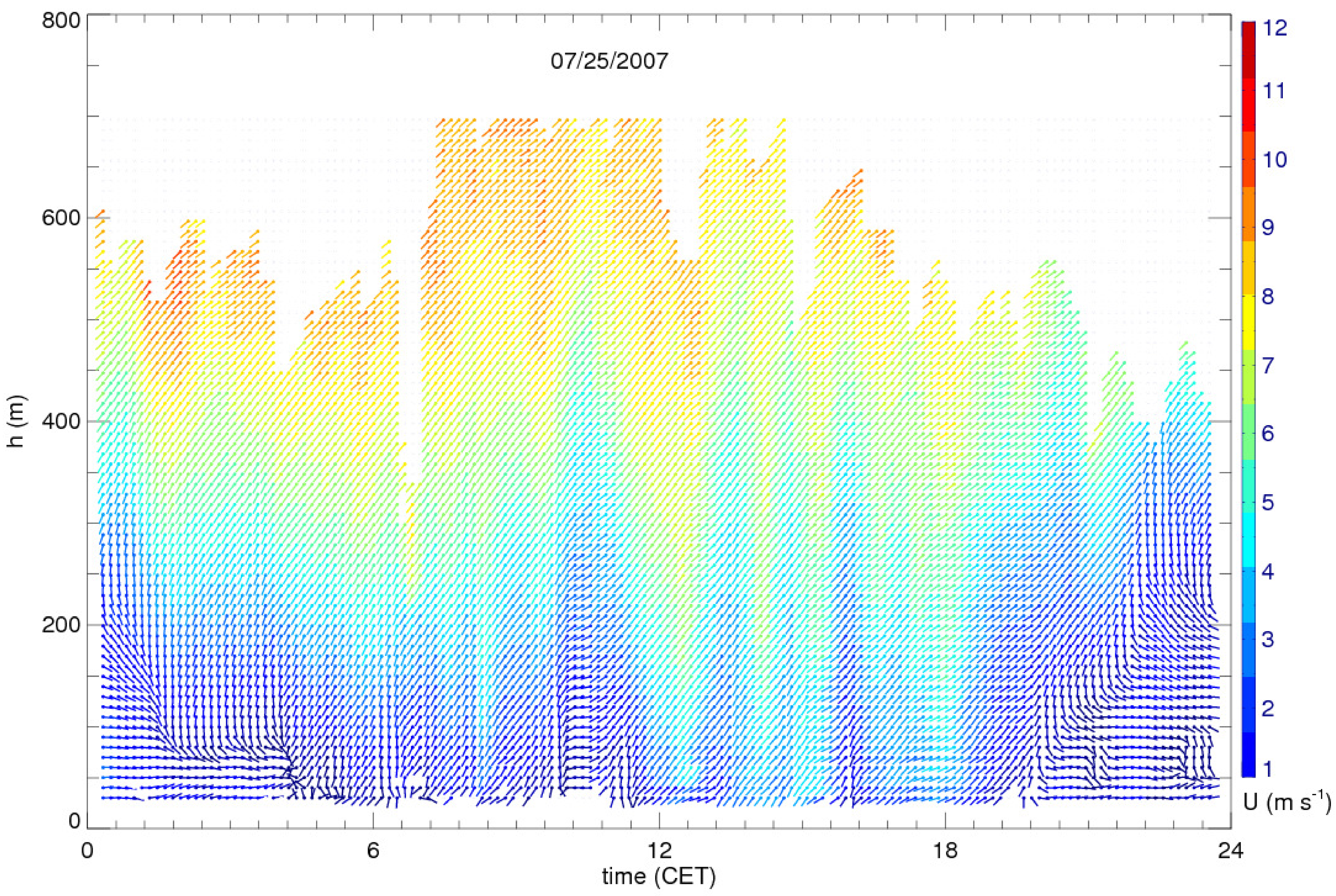

Figure 4: Diurnal course of wind speed and wind direction in the Renchtal Valley 7.25.2007, Colours indicate wind speed, wind direction is given by arrows

3. Results

In the lowest 500 m of the ABL, air flow of the Upper Rhine Valley is channelled due to the orientation of the Renchtal Valley. A comparison with datasets of the radiosondes started at the Achern site shows a good agreement of wind speed and wind direction above the local mountains. As an example Figure 1 shows wind speed and wind direction of the Oberkirch SODAR measurements and radiosonde data from 7.9.2007 11 CET.

In Figure 4 a typical diurnal course of wind speed and wind direction can be seen. On summer conditions, highest rates of velocity near the surface can be reached between 13.00 and 18.00 CET. Above 500 m a.g.l. maximum wind speeds can reach regularly more than 10 ms^{-1} (Figure 3 and 4). In contrast to night situations, the wind direction during daytime is almost homogeneous for the whole vertical profile. During nighttime local cold air masses contribute a down-valley flow from the Black Forest to the local wind stream pattern. These flows add an east component to the local wind field with increasing vertical extension of about 120-300 m until midnight.

Local modification of the air flow pattern by complex terrain can have an important role in producing shear, which generates turbulence and vertical mixing in the ABL. For July 2007, the means of U and (σ_w^2/U) for the time-ranges (00.10 - 8.00), (8.10 - 16.00) and (16.10 - 24.00) CET were calculated (Figure 3). For all time-ranges constant values of (σ_w^2/U) can be determined in the layer above 300 m a.g.l. The height of maximum σ_w^2/U values above ground can be assumed as the height of maximum turbulent exchange. Near surface peaks of (σ_w^2/U) can be detected between 100 m and 200 m for (0.10 - 8.00) and (16.10 - 24.00), whereas between 8.10 and 16.00 the maximum of (σ_w^2/U) can be seen at the surface with a linear decrease to a height of 300 m.

4. Conclusions

SODAR measurements of the three-dimensional wind field were carried out in summer 2007 in the Renchtal Valley as a contribution to COPS 2007. Comparisons with radiosonde Data shows a good accuracy of the SODAR data for heights up to 700 m a.g.l. Periodic down-valley streams during nighttime could be detected. These near-ground streams may be responsible for increased turbulent exchange on the transition to upper air masses.

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