Vertical profiles of the variance of the vertical wind component and turbulence intensities from sodar soundings in urban measurement campaigns

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The urban heat island is an important meteorological feature of larger cities. It influences the ventilation and the air quality inside the built-up areas as well as the interaction of the urban environment with its surroundings. The long-term in-situ measurement of vertical profiles and turbulent fluxes within the heat island several hundreds of metres above ground is not possible. Therefore models and ground-based remote sensing must fill this gap. Remote sensing data have to be the basis for evaluation and verification of the model results. This contribution will present several typical results from optical and acoustic ground-based remote sensing from urban measurement campaigns.

The presented data comprise:

- Mean wind speed profiles from sodar measurements over Hannover (Germany), Budapest (Hungary), and Paris airport (France). A typical feature is the strong vertical shear in the first hundreds of metres above ground due to the large surface roughness.
- Diurnal variation of wind speed in several heights above ground. The usual nocturnal decrease of wind speed near the ground is missing or at least considerably reduced because of a higher nocturnal level of turbulence.
- Mean vertical profiles of the variance of the vertical wind component over Hannover, Budapest, and Paris airport. A typical feature is the increase of this variance with height even at night times. This indicates that the urban boundary layer has very often an unstable thermal stratification.
- Diurnal variation of the variance of the vertical wind component. The nocturnal level of this variance is higher than over rural terrain.
- Mean vertical profiles and diurnal variation of turbulence intensity over Hannover, Budapest, and Paris airport showing the generally higher level of turbulence over urban areas.
- Diurnal variation of the vertical stratification of the entire boundary layer and the mixing layer height over Budapest from combined soundings with sodar and ceilometer.
- Statistical evaluations of the mixing layer height over Hannover.
- An attempt to derive the vertical profile of the vertical turbulent exchange coefficient from sodar measurements.

Literature

a) wind profiles

Emeis, S., 2001: Vertical variation of frequency distributions of wind speed in and above the surface layer observed by sodar. Meteorol. Z., 10, 141-149. DOI: 10.1127/0941-2948/2001/0010-0141

Emeis, S., 2004a: Vertical wind profiles over an urban area. Meteorol. Z., 13, 353-359. DOI: 10.1127/0941-2948/2004/0013-0353

b) mixing layer height

Emeis, S., M. Türk, 2004: Frequency distributions of the mixing height over an urban area from SODAR data. Meteorol. Z., 13, 361-367. DOI: 10.1127/0941-2948/2004/0013-0361

Emeis, S. and K. Schäfer, 2006: Remote sensing methods to investigate boundary-layer structures relevant to air pollution in cities. Bound-Lay. Meteorol., 121, 377-385. DOI: 10.1007/s10546-006-9068-2

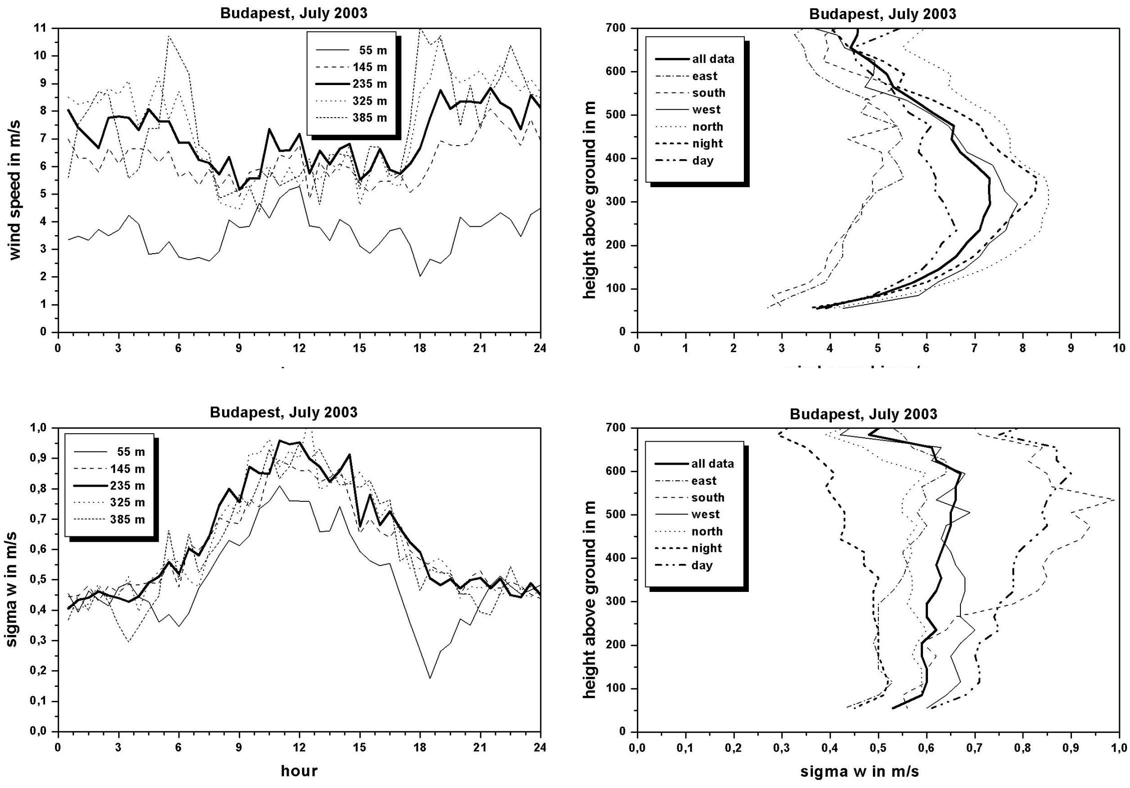
Schäfer, K., S. Emeis, H. Hoffmann, C. Jahn, 2006: Influence of mixing layer height upon air pollution in urban and sub-urban areas. Meteorol. Z., 15, 647-658. DOI: 10.1127/0941-2948/2006/0164

Piringer, M., S. Joffre, A. Baklanov, A. Christen, M. Deserti, K. De Ridder, S. Emeis, P. Mestayer, M. Tombrou, D. Middleton, K. Baumann-Stanzer, A. Dandou, A. Karppinen, J. Burzynski, 2007: The surface energy balance and the mixing height in urban areas – activities and recommendations of COST-Action 715. Published online in Bound.-Lay. Meteorol. DOI: 10.1007/s10546-007-9170-0

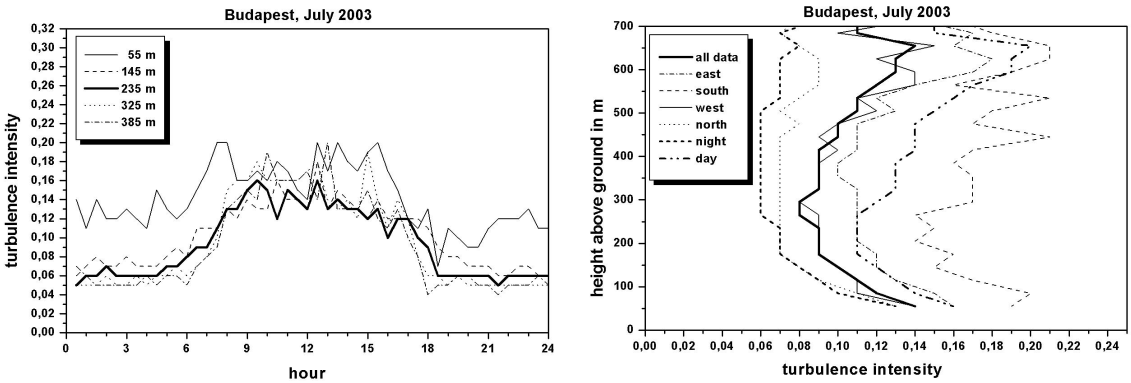
c) parameterization of turbulent exchange coefficients

Emeis, S., 2004b: Parameterization of turbulent viscosity over orography. Meteorol. Z., 13, 33-38. DOI: 10.1127/0941-2948/2004/0013-0033

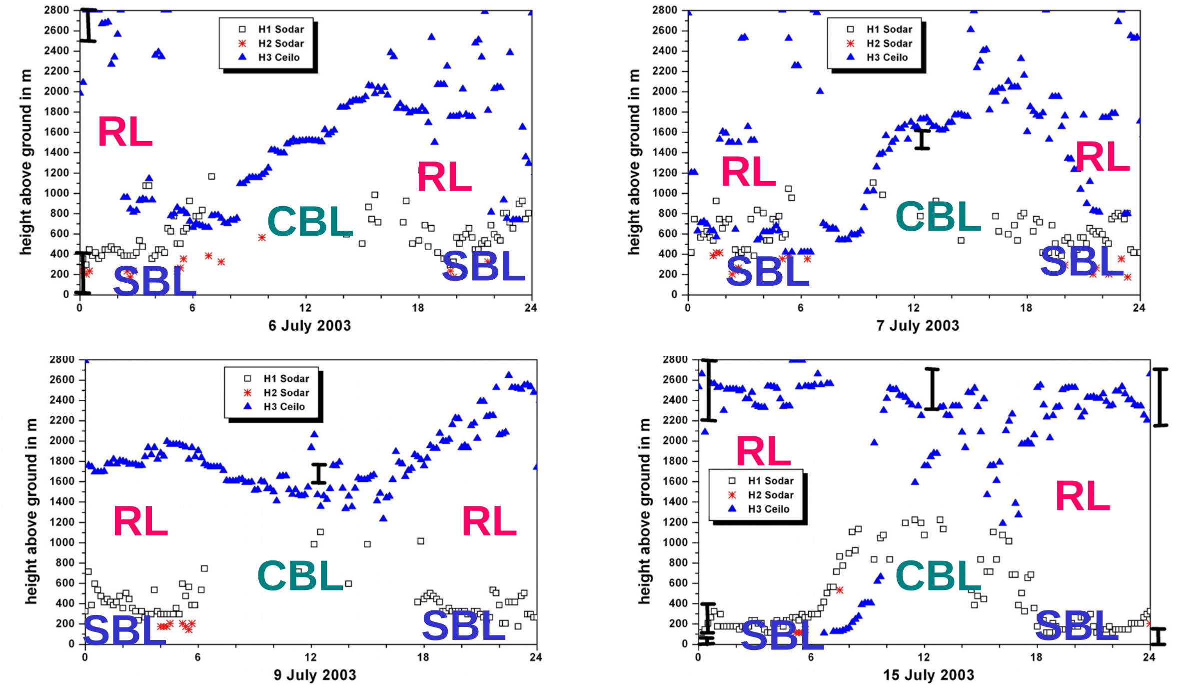
Figures



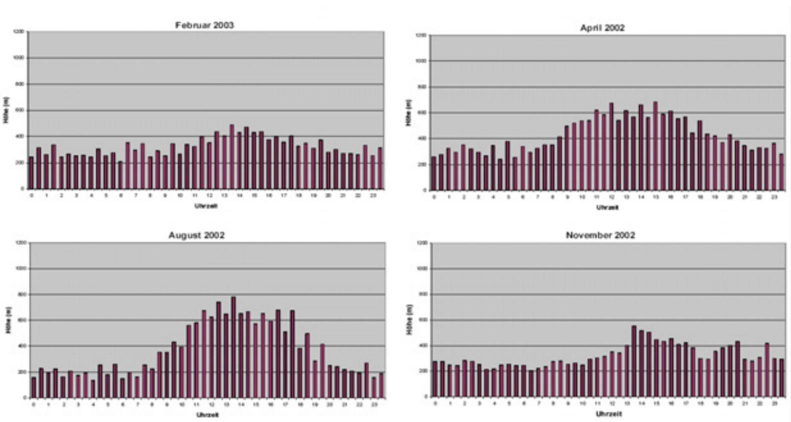
Diurnal variation (left) and vertical profiles (right) of mean wind speed (upper two frames) and variance of vertical wind component (lower two frames) over Budapest. Similar figures for Hannover can be found in Emeis (2004a).



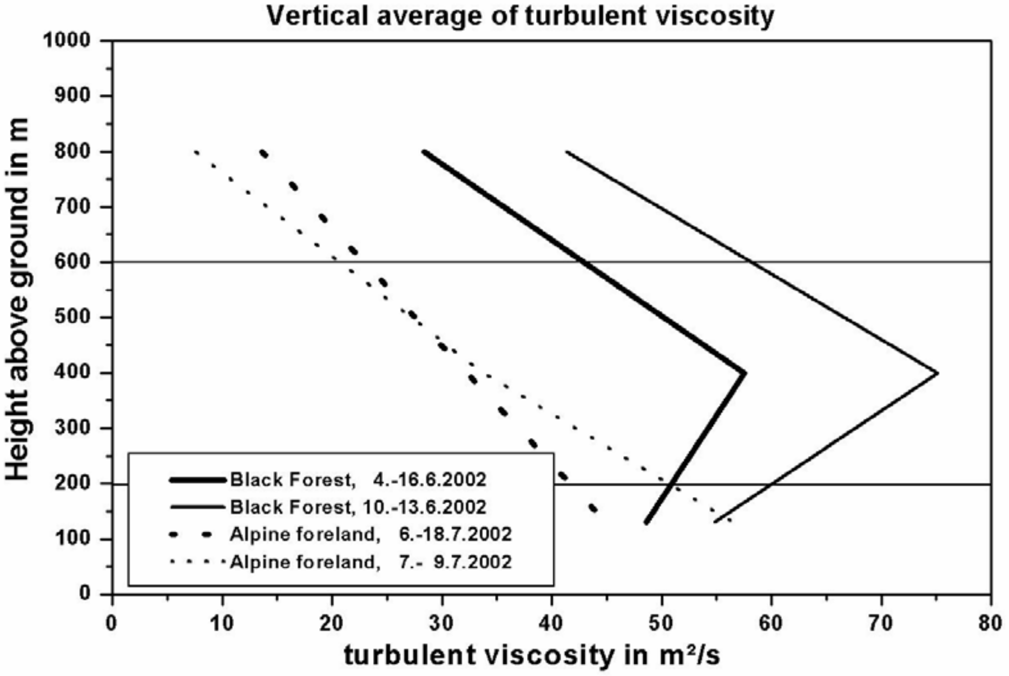
Diurnal variation (left) and vertical profiles (right) of turbulence intensity over Budapest.



Vertical structure of the entire boundary layer over Budapest on typical summer days from simultaneous measurements with a sodar (black open squares and red asterisks) and a ceilometer (blue triangles) from Emeis and Schäfer (2006).



Mean diurnal variation of mixing layer height over Hannover for the four seasons from sodar data (from Emeis and Türk 2004).



Estimated vertical profiles of the vertical turbulent exchange coefficient over level and highly complex terrain from sodar measurements (from Emeis 2004b).