Wind Tunnel Experiments in the Framework of SATURN

A contribution to subproject SATURN

F. Pascheke, B. Leitl, M. Schatzmann

Meteorological Institute of Hamburg University, 20146 Hamburg, Bundesstraße 55, Germany
e-mail: pascheke@dkrz.de

Summary

In the year 2001, the wind tunnel group of the Meteorological Institute of Hamburg University contributed to EUROTRAC-SATURN via project VALIUM "Development and validation of instruments for the implementation of European air quality policy in Germany" with the subproject "Evaluation and extension of field data on dispersion of pollutants acquired in a city district". VALIUM is the German core contribution to SATURN. It is sponsored by the German Federal Ministry of Education and Research within the frame of the Atmospheric Research Programme 'AFO2000'.

The purpose of VALIUM is the development of tools for urban air quality assessments according to the European Air Quality Guideline (96/62/EG) and its daughter directives. A system of consistent coupled numerical models will be developed (Trukenmüller et al, 2002).

In collaboration with the University of Stuttgart (IER), the Research Centre Karlsruhe (IMK4 Garmisch), the Lower Saxony State Agency for Ecology (NLÖ, Hanover) and a private Lohmeyer, Karlsruhe), a comprehensive data set for the validation of the model system will be generated, based on a combination of field and laboratory data. The laboratory experiments are carried out in the large boundary layer wind tunnel 'WOTAN' which was recently inaugurated at Hamburg University (Figure 1).

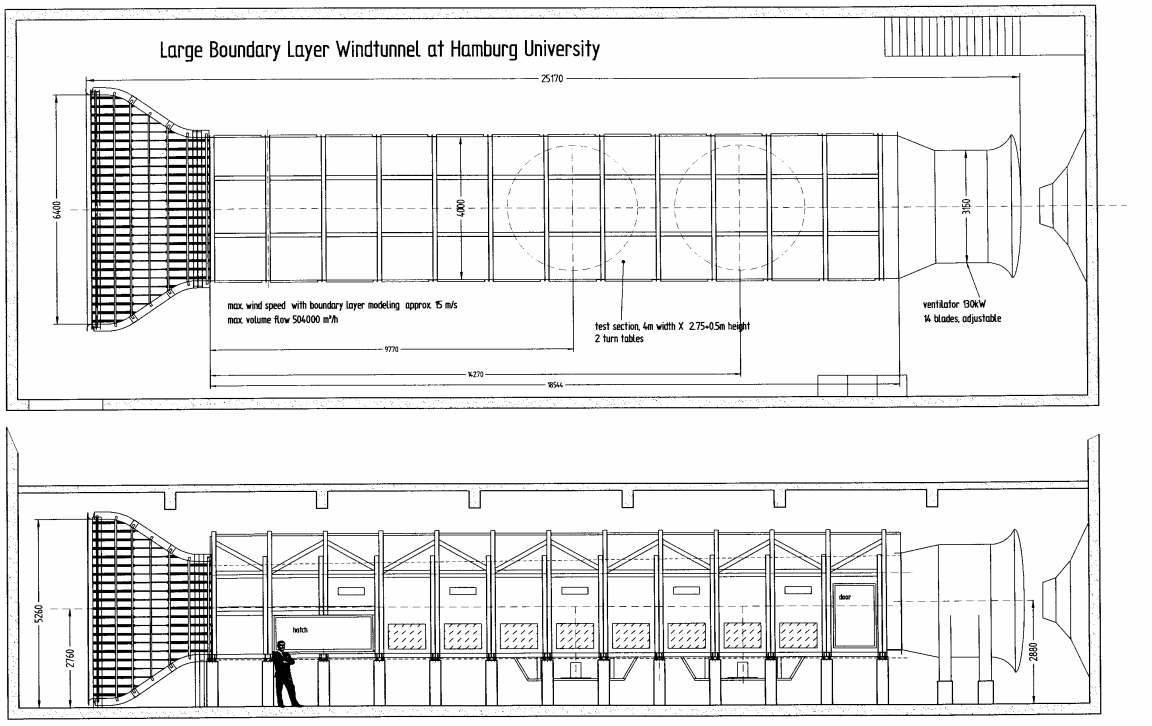

Figure 1: Sketch of the new boundary layer wind tunnel of Hamburg University.

Aim of the research

The field experiments are carried out in a city district of Hanover/Germany. It is the objective of the wind tunnel project (1) to support the field measurement campaigns by corresponding flow visualisation studies which help to determine optimal measurement positions, (2) to generalize and enhance the field data through laboratory experiments suitable to close gaps in meteorological situations not met during the field campaigns, (3) to replicate selected field situations and to vary certain parameters in a systematic way in order to improve the understanding of the governing flow and dispersion processes, and (4) to quantify the inherent scatter within the field data caused by the unsteadiness of meteorological conditions during the time interval of an individual experiment. At the end of the project (2003/04) a detailed data set comprising high resolution velocity and concentration fields measured inside the urban canopy layer will be made available to the EUROTRAC community via the world wide web.

Activities during the year

In 2001 a detailed aerodynamic model of the urban area was built. Figure 2 shows a small section of the model. The complete model covers an area of about 1 km x 1 km. A wind tunnel boundary layer corresponding to the model scale (1: 250) was generated utilizing a combination of vortex generators and floor roughness elements. The mean and turbulent boundary layer properties (wind profile, turbulence profile, roughness length, spectral density of the turbulent kinetic energy and integral length scales of all three components of the wind vector) were determined. In a tedious and time-consuming trial and error process, the vortex generators and roughness element distributions were repeatedly changed until an equilibrium boundary layer with properties characteristic for urban sites (Pascheke et al, 2001) was achieved.

Principal results

In addition to the well-documented wind tunnel boundary layer, only qualitative results from flow visualisation experiments are presently available.

Aims for the coming year

In the next year the first field campaign that took place August 8, 2001 will be replicated in the wind tunnel. Specific for this field experiment was a tracer release from a 96 m long artificial line source located a few cm above ground at the median strip of a busy urban street canyon (Bächlin, 2002). The field results (30 minute mean concentration and velocity values taken at several positions within the street canyon, line integrated DOAS and FTIR concentration values, SODAR wind component profiles) will be compared with corresponding wind tunnel measurements. In addition, component-resolving mean and turbulent velocity fields in several cross sections of the street canyon will be measured and documented. The results will form the basis for a complete validation data set that can subsequently be used for the validation of complex micro-scale flow and dispersion models.

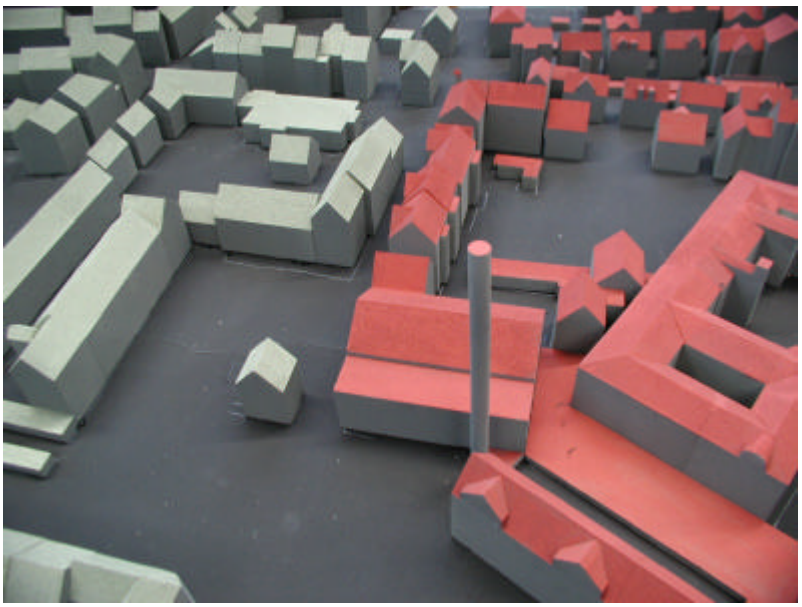

Figure 2: Part of the aerodynamical model.

Acknowledgements

Support from the German Federal Ministry of Education and Research (BMBF) is gratefully acknowledged.

References

Bächlin, W. (2002): Tracer Experiments within an Urban Street Canyon. - Field Measurements for Establishing a Validation Data Set - Experimental Realization. Poster, Symposium 2002 EUROTRAC-2, March 11-15 2002, Garmisch-Partenkirchen, Germany.

Cermak, J. E., A. G. Davenport, E. J. Plate, and D. X. Viegas, (1995): *Wind climate in cities.* Kluwer Akademic Publishers, 772 pp.

Leitl, B., and Schatzmann, M. (2001): Basic demands on boundary layer modelling and quality assurance in wind tunnel modelling with respect to micro-scale flow and dispersion studies. Proceedings, International Workshop on Physical Modelling of Flow and Dispersion Phenomena. Sept.3 - 5, 2001, Hamburg, Germany.

Pascheke, F., Leitl, B., and Schatzmann, M. (2001): Results from Recent Observations in an Urban Boundary Layer. Proceedings, COST 715 Workshop on Urban Boundary Layer Parameterisations, Zurich, May 24-25 (in print).

Plate, E. J. (Ed.), 1982: *Studies in Wind Engineering and Industrial Aerodynamics.* Vol.1, *Engineering Meteorology*, Elsevier Scientific Publishing Company, 740 pp.

Schäfer, K., S. Emeis, H. Hoffmann, C. Jahn (2002): Validation data for small-scale numerical and physical models of a quarter of a city. Poster, Symposium 2002 EUROTRAC-2, March 11-15 2002, Garmisch-Partenkirchen, Germany.

Snyder, W. H., 1981: Guideline for Fluid Modeling of Atmospheric Diffusion. US Environmental Protection Agency. EPA 600/8-81-009, 185 pp.

Trukenmüller, A., H. Schluenzen and D. Grawe (2002): A model system for evaluating air quality in different detail. Poster, Symposium 2002 EUROTRAC-2, March 11-15 2002, Garmisch-Partenkirchen, Germany.