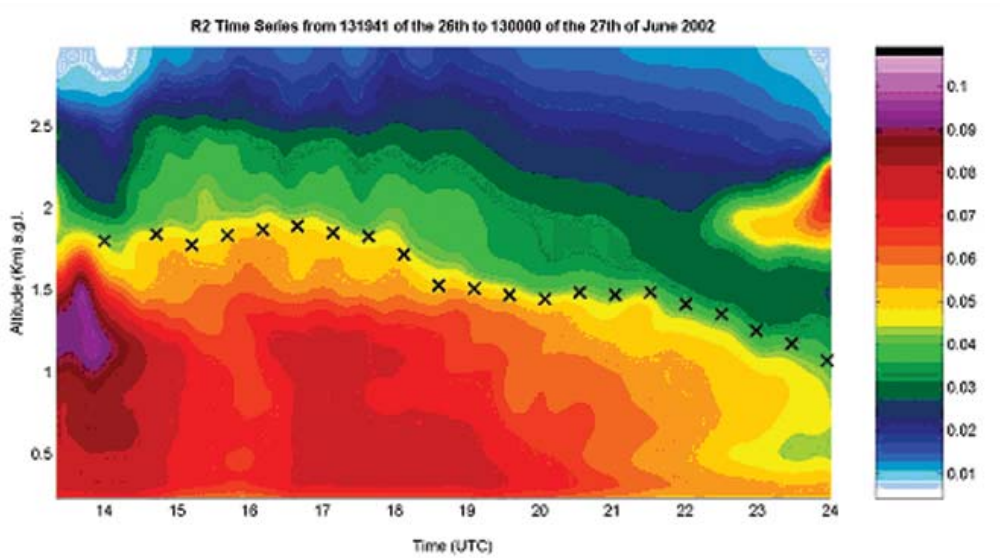
THE URBAN SURFACE ENERGY BUDGET AND MIXING HEIGHT IN EUROPEAN CITIES: DATA, MODELS AND CHALLENGES FOR URBAN METEOROLOGY AND AIR QUALITY

Final Report of Working Group 2 of COST-715 Action



EDITORS: Martin Piringer and Sylvain Joffre

cost

COST – the acronym for European **CO**operation in the field of **S**cientific and **T**echnical Research – is the oldest and widest European intergovernmental network for cooperation in research. Established by the Ministerial Conference in November 1971, COST is presently used by the scientific communities of 35 European countries to cooperate in common research projects supported by national funds. The funds provided by COST – less than 1% of the total value of the projects – support the COST cooperation networks (COST Actions) through which, with only around € 20 million per year, more than 30.000 European scientists are involved in research having a total value which exceeds € 2 billion per year. This is the financial worth of the European added value which COST achieves. A "bottom up approach" (the initiative of launching a COST Action comes from the European scientists themselves), "à la carte participation" (only countries interested in the Action participate), "equality of access" (participation is open also to the scientific communities of countries not belonging to the European Union) and "flexible structure" (easy implementation and light management of the research initiatives) are the main characteristics of COST. As precursor of advanced multidisciplinary research COST has a very important role for the realisation of the European Research Area (ERA) anticipating and complementing the activities of the Framework Programmes, constituting a "bridge" towards the scientific communities of emerging countries, increasing the mobility of researchers across Europe and fostering the establishment of "Networks of Excellence" in many key scientific domains such as: Physics, Chemistry, Telecommunications and Information Science, Nanotechnologies, Meteorology, Environment, Medicine and Health, Forests, Agriculture and Social Sciences. It covers basic and more applied research and also addresses issues of pre-normative nature or of societal importance.

COST-715 Action
Final Report of Working Group 2

Cover

LIDAR scans of the backscatter from the atmosphere on 26 June 2002. The measurements are performed in Basel during the BUBBLE experiment. The mixing heights as determined from the derivative of the range-corrected signal are indicated by crosses. *Courtesy V.Mitev, R. Matthey and G. Martucci, Observatory of Neuchatel, Switzerland.*

Cataloging data can be found at the end of this publication.

ISBN 954-9526-29-1

Printed in Bulgaria

THE URBAN SURFACE ENERGY BUDGET AND MIXING HEIGHT IN EUROPEAN CITIES: DATA, MODELS AND CHALLENGES FOR URBAN METEOROLOGY AND AIR QUALITY

Final Report of Working Group 2 of COST-715 Action

EDITORS: Martin Piringer and Sylvain Joffre

Lead Authors:
Alexander Baklanov, Jerzy Burzynski, Andreas Christen, Marco Deserti, Koen De Ridder, Stefan Emeis, Sylvain Joffre, Ari Karppinen, Patrice Mestayer, Douglas Middleton, Martin Piringer, and Maria Tombrou

Contributions by:
Kathrin Baumann-Stanzer, Giovanni Bonafè, Angela Dandou, Sylvain Dupont, Nicola Ellis, Sue Grimmond, Emmanuel Guilloteau, Alberto Martilli, Valéry Masson, Tim Oke, Victor Prior, Mathias Rotach, and Roland Vogt

THE URBAN SURFACE ENERGY BUDGET AND MIXING HEIGHT IN EUROPEAN CITIES: DATA, MODELS AND CHALLENGES FOR URBAN METEOROLOGY AND AIR QUALITY

EDITORS: Martin Piringer[1] and Sylvain Joffre[2]

Lead Authors:

Alexander Baklanov[3], Jerzy Burzynski[4], Andreas Christen[5], Marco Deserti[6], Koen De Ridder[7], Stefan Emeis[8], Sylvain Joffre[2], Ari Karppinen[2], Patrice Mestayer[9], Douglas Middleton[10], Martin Piringer[1], Maria Tombrou[11]

Contributions by:

Kathrin Baumann-Stanzer[1], Giovanni Bonafè[6], Angela Dandou[11], Sylvain Dupont[12], Nicola Ellis[10], Sue Grimmond[13], Emmanuel Guilloteau[14], Alberto Martilli[15], Valéry Masson[16], Tim Oke[17], Victor Prior[18], Mathias Rotach[19], Roland Vogt[5]

1. Central Institute for Meteorology and Geodynamics, A-1190 Vienna, Austria
2. Finnish Meteorological Institute, FIN-00101 Helsinki, Finland
3. Danish Meteorological Institute, DK-2100 Copenhagen, Denmark
4. Institute of Meteorology and Water Management, Regional Office, PL-30215 Krakow, Poland
5. Institute of Meteorology, Climatology & Remote Sensing, Univ. Basel, CH-4055, Basel, Switzerland
6. Agenzia Regionale Prevenzione e Ambiente dell'Emilia Romagna – Servizio Idro Meteorologico, I-40122 Bologna, Italy
7. VITO-TAP, B-2400 Mol, Belgium
8. Institut für Meteorologie und Klimaforschung – Atmosphärische Umweltforschung – IMK-IFU Forschungszentrum Karlsruhe GmbH, D-82467 Garmisch-Partenkirchen, Germany
9. Equipe Dynamique de l'Atmosphere Habitee, Laboratoire de Mecanique des Fluides (UMR CNRS 6598), Ecole Centrale de Nantes, F-44321 Nantes, France
10. Meteorological Office, Exeter, EX1 3PB, United Kingdom
11. Dept. of Applied Physics, Univ. of Athens, GR-157 84, Athens, Greece
12. Unité de Recherche EPHYSE, INRA, F-33883 Villenave d'Ornon, France
13. Dept. of Geography, Indiana University, Bloomington, IN, USA
14. ALSTOM Transport, F-59494 Valenciennes, France
15. Univ. of British Columbia, Vancouver, B:C., Canada V6T 1Z4
16. CNRM Meteo France, F-31057 Toulouse, France
17. Dept. Geography, Univ. of British Columbia, Vancouver, B.C., Canada V6T 1Z2
18. Instituto de Meteorologia, P-1749-077 Lisbon, Portugal
19. MeteoSwiss, CH-8044 Zürich, Switzerland

LIST OF CONTENTS

1. Introduction

Urban areas are the site of most anthropogenic pollutant emissions and where the vast majority of Europeran citizens live (ca. 70%). Consequently, there is a strong scientific, governance and societal need for accurate and effective assessments and forecasts of air pollution in urban areas. Urban meteorology and pollution are characterised by a number of fundamental parameters and their evolution in time, which all have specific problems as to their monitoring, representativeness, parameterisation and modelling. Within the joint European project COST-715[1] (Urban Meteorology Applied to Air Pollution Problems; COST-715, 2004), its Working Group 2 (WG2) addressed the specific problems of determining and simulating the surface energy balance and the mixing height, which are critical components in many algorithms and/or numerical models. The surface energy balance together with the surface temperature and heat fluxes determine the hydrostatic stability conditions in the lower atmosphere, which regulate the mixing of pollutants, whereas the mixing height parameter determines the available volume for pollutant mixing.

WG2 addressed these issues along the following lines:

- To review relevant theoretical concepts of the structure of the urban boundary layer.
- To review and assess pre-processors, schemes and models for determining the mixing height, the surface energy budget and the stability, which are available to the participants.
- To identify and review suitable data sets within and outside the group that could be used to test and validate the pre-processors and models.
- To carry out inter-comparisons and to summarise comparisons of different schemes against each other and against data under specific conditions.
- To assess the influence of certain specific effects such as complex topography, strong heterogeneity, slope effects and canopy trapping on surface properties and fluxes.
- To assess the suitability of remote sensing tools to estimate canopy characteristics and surface fluxes and the mixing height.
- To provide recommendations for the improvement of existing pre-processors and models and for the development of new schemes.
- To provide recommendations for planning and conducting field campaigns in order to fill the important existing gaps for empirical data of key parameters for urban air pollution.

[1] COST is an acronym for co-operation in the fields of science and technology

- To provide recommendations for developing meteorological monitoring able to representatively describe various fields and processes under urban conditions.
- To promote co-ordination of related activities in Europe of presently scattered works, objectives, and responsibilities.

In the course of this COST-Action, the working group participated in several experiments and organised 3 open workshops with external experts:

1. Surface energy balance in urban areas, Antwerp, Belgium, 12 April 2000 (COST-715, 2002a),
2. Urban boundary layer parameterisations, Zurich, Switzerland, 24-25 May 2001 (COST-715, 2002b),
3. Mixing height and inversions in urban areas, Toulouse, France, 3-4 October 2001 (COST-715, 2002c).

During this COST-715 Action (1998-2004), in parallel and beyond the scientific work *per se*, the participating groups had the possibility to compare their respective experience and gaps in data or models. Consequently, it was possible to bring together various expertise and tools in order to promote, coordinate and optimise intra-European synergy through cooperation between national research activities. This was a major benefit offered by the COST framework, which is the oldest (funded in 1971) and widest (including 35 Member States) European intergovernmental network (see `http://ue.eu.int/cost/default.asp` or `http://cost.cordis.lu/src/home.cfm`). This report does not aim to be exhaustive but is primarily related to activities of WG2 Members, the outcome of these workshops and recent experiments and includes also findings from the literature. It complements the COST 715 Final Report (COST-715, 2004) in which the overall picture of urban air pollution meteorology from the point of view of science and air quality applications is addressed.

The present report is structured in the following way: after a short description of the basic concepts and issues in Section 2, Section 3 introduces some of the methods treating the surface energy budget for urban conditions, Section 4 the methods available to determine the mixing height. Section 5 describes some of the major European campaigns for urban meteorology, Sections 6 and 7 show the empirical and numerical results for the surface energy balance and the mixing height, respectively. Section 8 describes the use of remote sensing methods in urban studies, and finally Section 9 presents conclusions and recommendations based on the previous findings.