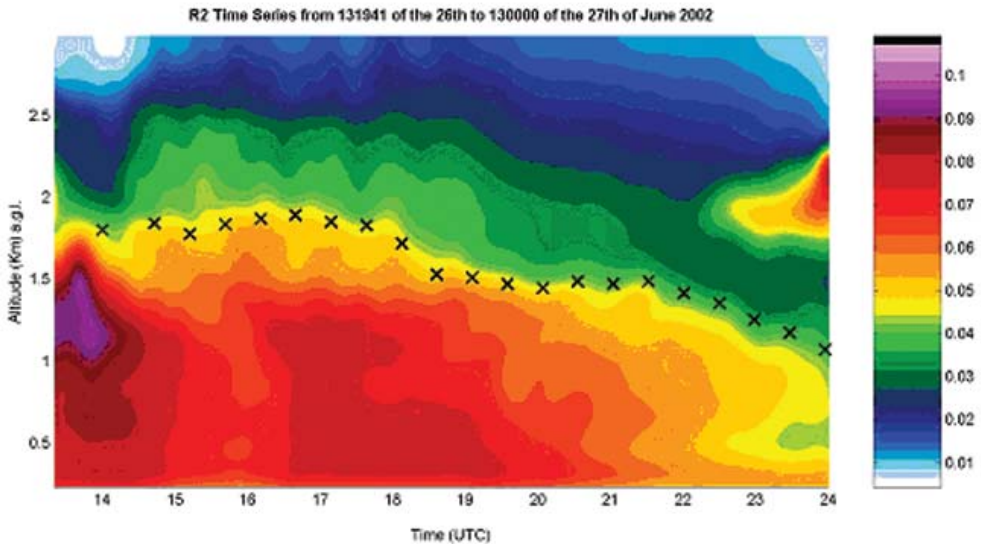


THE URBAN SURFACE ENERGY BUDGET AND MIXING HEIGHT IN EUROPEAN CITIES: DATA, MODELS AND CHALLENGES FOR URBAN METEOROLOGY AND AIR QUALITY

Final Report of Working Group 2 of COST-715 Action



EDITORS: Martin Piringer and Sylvain Joffre



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**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.*

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1. Introduction

Urban areas are the site of most anthropogenic pollutant emissions and where the vast majority of European 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-715¹ (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.

¹COST 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.