Minutes of the Forth COST 715 Meeting of Working Group 2, Greenwich, UK, 6 December 2000

Participants:

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Koen De Ridder
Sylvain Joffre
Ari Karppinen
Patrice Mestayer
Douglas Middleton
Martin Piringer
Maria Tombrou

Note: These minutes contain also decisions relevant for WG 2 made during the adjacent MCM on 7/8 December 2000.

1. MP opened the meeting and welcomed the participants.

2. The draft agenda was adopted without change and is given in Annex 1. The list of Working Group 2 members including full addresses (with minor changes) is given in Annex 2.

3. The minutes of the Antwerp meeting have been adopted with slight changes of the lines of activities (Annex 3). The revised lines of activities are added again as Annex 3 to the present minutes.

4. Review of Antwerp decisions:

   Antwerp expert meeting: Extended abstracts of the contributions have been collected, edited and sent in August 2000 to the COST secretary for publication with an ISBN number. The secretary will submit the abstracts to the printing office in January 2001. WG 2 regrets the delay of printing the abstracts.

   Final WG report: The latest draft of possible chapters of a final report is given in Annex 4.

   Study contract: see item 5.1.

   Workshop on mixing heights: see item 7.

   Co-operation: A joint WG meeting of groups 1 and 2 took place at Greenwich on 7 Dec. 2000 in the morning (see minutes by Mathias Rotach).

5. Reports:

   5.1 Study contract: The proposal adopted at Antwerp was discussed at the forth MCM at

Prague. The following changes and additions have been proposed: include the LUMPS pre-processor (Grimmond and Oke); use only urban data (Birmingham, Basle, Graz). The revised proposal was sent to the chair and the secretary of COST 715 in August 2000 (Annex 5). It was finally approved at Greenwich. The secretary will process the study contract in Januaeary 2001.

5.2 Basle and Escompte experiments: PM gave a brief overview. Details can be found in the minutes of the joint WG 1/2 meeting done by M. Rotach.

5.3 Mixing height: AB presented two new approaches of mixing height estimation for long-living SBLs developed in co-operation with S. Zilitinkevich and results of a comparison of 10 different formulations of the SBL height using a 3-year data set from Cabauw. An improved SBL height formula from Zilitinkevich seems to perform best. It was suggested to continue this work for urban data sets as a study contract.

SJ informed about an interesting way to diagnose boundary layer height over heterogeneous surfaces using surface fluxes and the Brunt-Väisälä frequency. This data analysis has been now accepted in Boundary-Layer Meteorology. The paper is entitled "Variability of the stable and unstable atmospheric boundary layer height and its scales over a boreal forest" by Joffre, S. M., Kangas, M., Heikinheimo, M. and Kitaigorodskii S. A.

DM compared BL heights and surface heat flux data from Manchester with results of the ADMS pre-processor. The data sets used could be valuable for WG 2.

5.4 Momentum flux: MT reported on her investigations of surface fluxes under shear-free conditions.

AB informed about results of the SFINCS project to improve surface flux parameterisations for the SBL.

5.5 Loutraki Urban Air Quality Conference, March 2001: MP presented a draft of an extended abstract highlighting the main tasks and achievements of WG 2. The final version obtained after vivid discussions and including contributions of WG members was sent to the programme committee and is given in Annex 6.

Due to lack of time, the other items were only touched briefly. Most notably, KR reported on a project accepted by the EC to be carried out within the 5th Framework Programme: "Benefits of Urban Greenspace BUGS". Decisions resulting from the WG meeting are summarised below:

6. Decisions:

   Planned workshop: The WG decided to apply for a workshop on mixing heights preferably to be held in autumn 2001. At the MC, two workshops have been decided to take place in connection with the next two MCMs. The first on urban boundary layer parameterisations, Zürich, 24/25 May 2001, jointly organised by WG 1 and WG 2 (local organiser: M. Rotach); the second on mixing heights with special emphasis on peak pollution episodes, Toulouse, 4 Oct. 2001, jointly organised by WG 2 and WG 3 (local organiser: Meteo France).

   Final report: The WG decided to update the responsibilities for the proposed chapters of the final report (Annex 4).

   WG 2 web page: AK volunteered to draft the web page for WG 2. MP adopted it on 15 Dec. 2000. The address is: http://cost.fmi.fi/wg2. The WG appreciates AK for doing this job in very short time.

   Planned STSM: The STSM of Kathrin Baumann, ZAMG Vienna, to the UK Met. Office to work on the Birmingham data set in preparation for the study contract will take place during spring 2001. It will be prepared jointly by DM and MP. MP encouraged the other WG members to apply for STSMs or to reflect on possible new study contracts.

7. The next WG 2 meetings will be conducted together with the next workshops and MCMs.

Annex 1: Agenda

1. Welcome of participants
2. Adoption of agenda
3. Adoption of minutes of WG2 meeting at Antwerp
4. Review of Antwerp decisions
5. Reports and discussions:

5.1 Study contract (MP)

5.2 Basle and Escompte experiments (PM, SJ see also joint meeting)

5.3 Mixing height: Cabauw data (AB), AK, MP

5.4 Momentum flux (MT)

5.5 Loutraki abstract

6. Recommendations: Surface energy balance
7. Planned workshop on mixing heights
8. Final report: responsibilities (continued), expert meeting
9. WG 2 web page
10. Planned short-term scientific missions, study contracts
11. 5th framework programme (KD, AB?)
12. Workplan until next WG 2 meeting
13. Report on past and future symposia/conferences related to WG 2 topics
14. Date and place of next meeting
15. AOB

Annex 2: List and addresses of participants

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Annex 3: Lines of activities of WG 2

a) To review theoretical concepts of the structure of the urban boundary layer.

b) To review and assess pre-processors, schemes and models for determining the mixing height, the surface energy budget and the stability that are available to the participants. Cases of strong stability and/or windless conditions are of special interest.

c) To review theoretical models together with available field measurements and LES for calculation of the minimum friction velocity and the heat transfer coefficient. Conditions of shear free convection over high roughness are of main importance

d) TTo identify and review suitable data sets within and outside the group that could be used to test and validate the pre-processors and models.

e) To carry out intercomparisons and to summarise comparisons of different schemes against each other and against data under specific conditions.

f) To assess the influence of the model outputs of certain specific effects such as complex topography, strong heterogeneity, slope effects and canopy trapping on radiative fluxes.

g) To assess the suitability of remote sensing tools to estimate canopy characteristics and surface fluxes.

h) To provide recommendations for the improvement of existing pre-processors and models and for the development of new schemes.

i) 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.

j) To promote co-ordination of related activities in Europe of presently scattered works, objectives, and responsibilities.

Annex 4

COST-715 WG 2
Draft outline of structure of final report

Executive summary
List of figures
List of tables
List of acronyms and symbols
1. Introduction
2. Review of theoretical concepts of the structure of the urban boundary layer (PM)
3. Review and assessment of pre-processors, schemes and models for the surface energy budget (SJ, PM, AK)
    - 3.1 The surface energy budget
    - 3.1.1 Surface radiation budget
    - 3.1.2 Surface sensible flux
    - 3.1.3 Surface latent heat flux
    - 3.1.4 Storage term
    - 3.1.5 Anthropogenic flux
    - 3.2 Surface temperature
    - 3.3 Temperature roughness
    - 3.4 Input data requirement
4. Review and assessment of pre-processors, schemes and models for determining the mixing height (AB, SJ, MP, AK)
    - 4.1 Methods based on radiosoundings
    - 4.2 Methods based on parametrisation schemes
    - 4.3 Methods based on NWP model outputs
    - 4.4 Input data requirement
5. Review and assessment of available empirical data (AB, AK, MP)
    - 5.1 The urban surface energy budget and its components (RV)
    - 5.2 The mixing height
    - 5.3 Required ancillary data
6. Results of intercomparisons of different schemes against each other and against data (AB)
    - 6.1 The surface heat flux (MP)
    - 6.2 The mixing height (MP, SJ)
7. Influence of specific disturbances on model outputs
    - 7.1 Effect of strong heterogeneity on radiative fluxes
    - 7.2 Effect of internal boundary layer development on the mixing height
    - 7.3 Effect of complex terrain features
8. Assessing the suitability of remote sensing tools to estimate canopy characteristics and surface fluxes (KR, RV)
9. Recommendations and needs (SJ, PM, AK)
    - 9.1 Improvement of existing pre-processors, schemes and models for the surface energy budget
    - 9.2 Improvement of existing pre-processors, schemes and models for the mixing height
    - 9.3 Outlook for development of new schemes
    - 9.4 Improvement of input data availability and quality for research and model validation
    - 9.5 Monitoring strategy for required parameters
    - 9.6 Need and planning of future field campaigns (RV)

List of references

Appendices:
- A1 Short description of pre-processors and models referred in this report
- A2 Documentation on data sets suitable for testing and validating pre-processors and models

Annex 5: Study contract proposal

COST 715 Study Contract

Proposal

Validation of net radiation and sensible heat flux parameterisation with measured data in three European cities

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Validation of net radiation and sensible heat flux parameterisation with measured data in three European cities

1. INTRODUCTION

Dispersion in the atmospheric boundary layer is affected by the geostrophic wind, which governs the large-scale advection of air in the atmosphere and the surface sensible heat flux, which determines the stability and convection in the boundary layer. In recent years, a number of schemes have been developed to estimate net radiation, sensible heat flux and other PBL parameters from hourly standard meteorological data. Working group 1 of COST 710 conducted an intense comparison of these methods and presented various validations against observational data. The outcome of these comparison studies regarding the planned investigation is summarised in section 2.1. Most of these models were developed based on experimental data from flat, grass-covered environment. Working group 1 of COST 710 states that the conventional methods are limited to horizontal homogeneity: "Urban areas need special attention within the problem of complex topography. Concerning the task of determining the surface energy balance in urban areas, no operational tools are available at present." Recently, schemes for the urban boundary layer are under development. These are introduced in section 2.2.

Measurements of the turbulent fluxes over a longer time period in the urban boundary layer are available in the three European cities Birmingham, Basle and Graz. These data-sets offer the possibility to validate parameterisation schemes over time periods of several months each, during different seasons and for urban settlements under different climatic conditions: Birmingham represents a highly industrialised site in maritime climate, Basle is also an industrial city situated in hilly terrain in Central Europe, and the smaller city Graz is situated in a basin south of the Alpine ridge influenced by terrain-induced flow regimes.

2. BACKGROUND

2.1PBL parameterisation over homogeneous surfaces in Europe

The Berkowicz and Prahm heat flux method (BP) was developed based on measured flux data from Hojbakkegaard in Denmark; Marsta in Sweden and Cabauw in the Netherlands (Berkowicz and Prahm, 1982). The Holtslag and van Ulden (Holtslag and van Ulden, 1983; Van Ulden and Holtslag, 1985; De Rooy and Holtslag, 1999) heat flux method was developed using mainly data from Cabauw in the Netherlands. The schemes have been tuned to data from these sites. Although the data cover a broad range of weather conditions, they originate only from a grass-covered environment.

For the UK Galinski and Thomson (1995) have done that kind of investigation. They had almost 3 years of data available from Cardington. Their general conclusion was that the results from all tested pre - processors show a useful correlation with measured heat fluxes during daytime (neutral or unstable conditions), although the scatter is quite large. During night-time (stable conditions) the correlation between calculations and measurements are worse. When comparing the schemes with each other, they conclude that the BP heat flux method performed best during daytime conditions while the HU83 heat flux method performed best during night-time.

The parameterisation of the soil moisture turned out to be a major problem. The HU83 scheme does not take into account soil moisture at all where as the BP scheme tries to take into account soil moisture via the ‘integrated hourly net radiation since last recorded rainfall’, but not really successful. The decrease of model performance with decrease in relative humidity is explained by the plant reaction with increasing dryness. The stomata are closed to protect the plant from desiccation which results in a reduced latent heat flux and an increase in sensible heat flux. As a result the pre - processors underestimate the sensible heat flux under dry stress conditions. More advanced schemes, which are mostly applied in GCMs, do consider this mechanism (Chen et al, 1997; Acs and Hantel, 1998).

The Finish Meteorological Institute (FMI) developed a boundary-layer parameterisation model based on the HU method (Karppinen et al., 1997). Net radiation was predicted equally well by the FMI pre - processor and the Danish OML pre - processor. Substantial differences occurred for the sensible heat flux. The ratio of stable to unstable situation as evaluated by the two models is almost the same. In stable conditions, the OML model produces more negative energy flux values than the FMI model. In unstable conditions, the FMI model produces larger turbulent heat flux values than the OML model. The results indicate that the two parameterisation schemes divide the available energy between the latent and sensible heat fluxes differently. There exists a clear difference between both models concerning the Monin-Obukhov lengths, whereby the FMI model does not produce a cut – off towards very stable condition as does the OML.

The MEPDIM pre – processor of the Norwegian Institute for Air Research (NILU) offers two modes of operation, which are either a profile or an energy budget method (Bohler and Guerreiro, 1997). MEPDIM was tested against flux data from an island off the Norwegian coast. Observed and modelled dispersion coefficients were compared. Under stable condition results were best and under unstable conditions the sigma values were overestimated.

Johansson (1997) evaluated the performance of the FMI and the SMHI (Swedish Meteorological and Hydrological Institute) pre - processors under typical winter conditions in northern Europe. The calculated net radiation and heat fluxes were lower than the observed values and the disagreement between the two pre - processors was large. The pre – processors had to be modified to cope with the special atmospheric conditions of Skandinavian winters.

The OML and the FMI pre – processors were validated for spring and summer flux observations in southern Sweden (Erbes and Pechinger, 1998). Generally the calculated sensible heat fluxes tended to be lower than the measured ones. The OML tends to give lower values than measured for near-zero as well as for high heat flux values. The FMI scheme produces good results for the near-zero fluxes during night time and with overcast skies, while the estimates are poor for positive fluxes during daytime clear-sky cases with a higher incoming solar radiation.

Although standardised methods for the comparison of various types of pre – processors with different data sets do not exist, the following table could be compiled from available literature and might offer some idea of the model performance at various sites in Europe (r^2. stands for the variability explained by the model, RMSE for the root mean square error; bias and RMSE are in Wm^{-2}).

Table 1: Results from pre-processor validation studies at different European (rural) sites.

Authors	Scheme	Net Radiation				Sensible Heat Flux			
			r^2	Bias	RMSE		r^2	Bias	RMSE
Galinski and Thomson (1995), UK	HU83	with cloud observation	0.85	+27.2	66.2	day	0.59	-16.7	45.5
	HU83	with measured short wave radiation	0.94	+5.2	35.9	night	0.38	-2.6	13.1
	BP	With cloud observation	0.86	+26.2	64.9	day	0.66	-8.0	38.5
	BP	With measured short wave radiation	0.94	+10.3	38.0	night	0.22	-14.8	22.0
Holtslag and van Ulden (1983), Nether-lands	HU83	With cloud observation	0.73	+7.9	63.2	day	0.41	+4.1	34.0
	HU83	With measured short wave radiation	0.96	-8.9	24.8	night	0.64	-1.1	26.0
De Rooy and Holtslag (1999), Nether-lands	HU85	With measured short wave radiation	-	-	-	All data	-	+1.6	13.4
	HU99	With measured short wave radiation	-	-	-	All data	-	+2.5	18.1
Fisher et al. (1998), Sweden	OML	With cloud observation	0.83	-	-	All data	0.70	-	-
	FMI	With cloud observation	0.58	-	-	All data	0.51	-	-
Acs and Hantel (1998), Nether-lands	PROG-SURF	With measured short wave radiation	0.99	+5.74	-	All data	0.71	+2.6	-

2.2 PBL parameterisation in urban areas

Grimmond and Oke (2000) developed a linked set of equations to calculate heat fluxes, and thereby atmospheric stability, specifically designed for the urban environment. The scheme is basically a further development of the approach by Holtslag and van Ulden. This pre-processor scheme (LUMPS for **L**ocal-scale **U**rban **M**eteorological **P**re-processing **S**cheme) makes use of parameterisations that, in a similar way as the pre-processors mentioned above, require standard meteorological observations, but additionally basic knowledge of the surface character of the target urban area. Ideally the scheme is driven by measured short- or net radiation but these fluxes can also be modelled. Heat storage by the urban fabric, including hysteresis, is parameterised from the radiation and surface cover information. The turbulent sensible and latent heat fluxes are calculated using the available energy and a simplified Penman – Monteith / Priestley – Taylor type of equation using a measure of the surface moisture status, given by the fraction of the surface covered by vegetation, and temperature. LUMPS has been evaluated using data from North American cities. LUMPS is still in a stage of development, and rather than to apply it to large data sets, it should be tested in single interesting situations in different European cities.

Therefore it is very desirable to test the pre–processor schemes BP and HU not specifically designed for the urban environment against LUMPS in as many data sets from different urban sites as possible to gain insight in the possible improvements achievable by LUMPS. It would also be of use to know, which parameterisations are most sensitive to changes of which environmental variables.

Grimmond and Oke (2000), from their application of LUMPS to seven North-American cities, conclude that the new scheme is a significant improvement over earlier, widely used models such as HPDM (Hanna and Chang, 1993). They attribute this improvement largely to a greater understanding of urban energetics derived from their multi-site urban data base, and to improved parameterisations of the storage heat flux, improved partitioning of sensible and latent heat fluxes across a range of surface covers, and improved parameterisation of the surface roughness.

3 OBJECTIVES

The HU and BP schemes have been tuned with data from fairly homogeneous, flat and grass covered terrain. These schemes are widely used in Europe, the computer codes are available, and runs for larger time series can easily be undertaken. Their performance in urban environments in Europe, however, is not checked against experimental data. Therefore the HU and BP schemes are to be compared with measured net radiation and sensible heat flux data from three different cities in Europe. The relationship of observed and modelled time series will be quantified with various statistical parameters, measuring the model performance (e.g. r^2, RMSE, bias). The model performance will be validated as a function of site, season and day time.

The LUMPS scheme will be applied to specific meteorological situations typical or of special interest for the three cities. In Graz, for example, low wind speed situations are of primary interest as they might cause enhanced levels of pollution (Piringer and Baumann, 1999). Special attention will be paid to the applicability of LUMPS to European data bases. As above, results will be compared to measured net radiation and sensible heat flux data as well as against the results of the BP and HU schemes.

Based on the results from the above objectives a comparison and a judgement of the performance as well as the applicability (with respect to data availability including land use and other surface descriptors) of the different schemes will be undertaken. Ideas for further possible improvements will be looked for and which kind of modifications would make a pre – processor fit to work reasonably well in an urban environment.

4 DATA

In the table below the required input data and the output parameters of pre – processors are listed.

Table 2: Input and output parameters of meteorological pre – processors and instrumentation.

Input parameter	**Source**
Global radiation	Next meteorological station
wind speed in 10 m gnd	
Temperature in 2 m gnd	
Relative humidity in 2 m gnd	
Pressure	
Terrain height	
Land - use type	
Roughness length	
Output parameter	**Measured data for comparison**
Net radiation	radiation measurements
Vertical flux of sensible heat	Sonic anemometer
Monin – Obukhov length	
Friction velocity	
Mixing heights	-

Main emphasis will be put on the comparison of the estimated net radiation to observations and the validation of the heat flux parameterisation with ultrasonic anemometer data. Furthermore, the pre-processors calculate the Monin-Obukhov length and the friction velocity. Ultrasonic anemometers also render these parameters which will be compared to the model results as side-check. No validations of mixing height estimates are planned in the present study.

Observational data from the cities Birmingham, UK, Basle, Switzerland, and Graz, Austria will be used for validation. The three site's meta data are compiled in Table 3.

In co-operation with the groups which were responsible for the data acquisition, input data (see table 2) and time periods for the pre-processor runs will be defined. In this context, the spatial representativity of the input data and of the measured data which will be used for comparison has to be discussed.

When air passes over inhomogeneous terrain, borderlines between different surfaces cause the formation of internal boundary layers. As a consequence the turbulence in the lowest portion of the atmospheric boundary layer is primarily influenced by the local (underlying) surface, while the turbulence in the upper layers remains similar to the conditions above upwind surfaces. Because of this "leading edge" or "fetch" – effect (Oke, 1987), in situ turbulence measurements have to be interpreted as a composite of fluxes from different upwind surfaces. Turbulence measured 10 m or more above the canopy is influenced by a relatively large area. The lower the instrument is mounted, the closer is the source area to the site. Gash (1986) gives an analytical solution for the variation of the influence dF/dx (in percent per meter) of different source areas on a turbulence measurement depending on the height z (m) of the instrument above ground, the mean wind speed $\bar{u}$ (m/s), the friction velocity u_* (m/s) and the distance x (m) of the source area from the site:

$$\frac{dF}{dx} = 100\,\frac{\bar{u}\cdot z}{k u_* x^2}\cdot e^{-\frac{\bar{u}\cdot z}{k u_* x}}$$

where k is the Von Kármán constant.

This concept is primarily valid only in neutral stratification. Under convective conditions, the measured flux is mostly representing the immediate surroundings of the site (approx. 50 m) due to the well mixed boundary layer. When the stratification is stable, the most dominant source area for the same turbulence measurements is situated about 400 to 500 m upwind.

As the typical structure of most European cities is highly inhomogeneous, these aspects will be considered in a first step in a more or less qualitative way (e.g. evaluating time-series divided into different wind direction sectors and separated for different weather conditions).

Table 3: Compilation of the three site's meta data:

Meteorological data	**Birmingham**	**Basle**	**Graz**
Begin – end Duration	980408 – 980430 23 days 990120 – 990216 28 days July 2000	a) 1993 - today b) July 95 - February 96	980331 – 980817 139 days
Co-ordinates	52,51°N 1,814°W	47,55°N 7,58°E	47,05°N 15,438°E
Site name	Dunlop tyre factory, NE Birmingham	a) MCR Lab, 18 m high tower on top of 15 m high building b) antenna tower	Puchstraße, Graz, Styria
Site description	Urban environment, industrial and retail complexes, instruments on 100 x 50 m grass-land area	a) close to centre of Basle, 15 to 20 m high buildings b) 50 high tower 24m above street level	Urban environment, grass covered plot
Radiation data	**Birmingham**	**Basle**	**Graz**
Begin – end Duration	Same periods and site as above	at tower a) in 33 m, periods and site as above	971215 – 990119 390 days
Site name			Puntigamer Str./Casalgasse, Graz, Styria
Site description			Urban environment, light industrial area

Birmingham

At Birmingham, the three wind components were measured with Gill ultrasonic anemometers at 15 and 30 m in 1998, and at 15 and 45 m in 1999 (the 30 m sonic anemometer would not work properly in 1999). PT100 resistance thermometers measured temperature one meter below surface and, screened and ventilated, on concrete slab, at 1.5, 15 and 30 m in both years, and additionally in 1999 on grass surface and at 45 m. Net radiation with a radiation balance meter and upward and downward short wave radiation with pyranometers were measured at 15 m. Additionally in 1999, a dew point hygrometer measured relative humidity at 1.2 m, a pressure transducer measured air pressure at 1 m, and a Tipping Bucket rain gauge measured rainfall at ground level. From these measurements, sensible heat flux, friction velocity, roughness lengths, and Monin-Obukhov length are derived.

Basle

In 1993 a measurement programme was started at the building of the MCR Lab. The site is located close to the centre of Basle and the surrounding area consists of building blocks with inner yards with building heights in the range of 15 to 20 m. The instruments are fixed to an 18 m high tower, which is mounted on the uppermost terrace of a five-story building. The tower base is at 15m above street level. The measurements started with three levels, and in summer 1994 two additional levels were installed. On top of the tower at 35 m a three dimensional ultrasonic anemometer, briefly sonic, (Solent, Standard) recorded continuously with 1 Hz the wind vector, and all raw data were stored.

From August, 16 to September 27, 1994, three different types of Solent ultrasonic anemometers mounted on top of the tower were compared. From October 5, 1994, on two Solent ultrasonic anemometers (Standard, 1 Hz; Enhanced, 4 Hz) including measurement of temperature fluctuations are operated at 34 and 28 m storing first and second moments on a 30 minute basis.

During July 1995 a second site has been instrumented. A 50 m antenna tower located 24 m above street level supports three ultrasonic anemometers (Solent, Research; 21 Hz) at three heights and wind speed, temperature and humidity measurements at six heights.

Graz

At Graz, a mast was equipped with an ultrasonic anemometer (METEK, USA-1) at 10 m above ground and with radiation balance (Ph. Schenk instrument, Type 8110), temperature, moisture and pressure sensors at 2 m above ground. The site is located 2 km south of the Graz city centre in a mixed residential/industrial area. A meteorological station was operated at another site nearby, about 1 km away.

The hard- and software for the analysis exist at CIMG and the HU and BP schemes are available for comparison purposes. The LUMPS scheme is kindly provided by the authors and will be installed and tested at our institute.

5. SCIENTIFIC PERSONNEL

Kathrin Baumann is holding a master degree in meteorology and mathematics and has accumulated experience since 1992 in the Department of Environmental Meteorology at the Central Institute for Meteorology and Geodynamics while working on various projects (including the Graz field experiment) related to boundary layer meteorology (e.g. participation in the Mesoscale Alpine Programme) and dispersion modelling (e.g. adaptation and validation of meteorological pre-processors for regional ozone modelling).

6. SCHEDULE

Estimated duration of the project: 6 months

Time required	**Work to be done**
2 months	preparation of the pre-processor runs, compilation of input data A COST STSM will be undertaken to study the Birmingham site and the data set. Information on the Basle data set is available from the University of Basle's web page; contacts with R. Vogt from the University have been established for necessary assistance. The Graz data set has been created by the applicant.
2 months	Pre – processor runs with all schemes (HU, BP, LUMPS) for selected periods (depending on available observational data) for the 3 sites. Modelled and observed time series are compared and evaluated with statistical quality parameters (for instance RMSE, bias, common variance). The influence of changing season, day time (day, night), weather conditions (wind, stability..) on the performance of the pre – processors are investigated.
2 months	The essential and final step consists in the evaluation of the pre – processors. In particular a judgement has to be made whether and how far the LUMPS scheme is superior to the HU and BP schemes in an urban environment. The performance and applicability of the schemes will be compared, whether they are suited for urban sites in Europe and in case they are not, where improvements could be implemented most efficiently; which of the assumptions they are based on do not hold and have to be modified.

7. COSTS

All computing equipment and data necessary for this project do exist at the Central Institute for Meteorology and Geodynamics. Financing is required for six month's remuneration of Mag. K. Baumann (EUR 23000).

8. REFERENCES

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Annex 6: Loutraki Urban Air Quality Conference Extended Abstract

The Surface Energy Budget and the Mixing Height in Urban Areas: Status report of Working Group 2 of COST-Action 715

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1. Introduction

COST ("Co-operation in the fields of Science and Technology") is a framework for scientific and technical co-operation, allowing the co-ordination of national research on a European level and to encourage and facilitate mutual scientific exchange among participants. COST Actions consist of basic and pre-competitive research as well as activities of public utility. COST funds co-ordination and networking but not the research itself. The main scientific goals of a COST Action are fixed in a "Memorandum of Understanding", to be signed by at least five COST Member States. An action lasts in general five years. Started in November 1998, COST Action 715 "*Meteorology applied to urban pollution problems*" has been signed by 19 countries and will end in September 2003. Action 715 is chaired by Bernard Fisher, UK Environment Agency, and co-chaired by Michael Schatzmann, University of Hamburg, Germany.

The core objective of Action 715 is to increase knowledge of, and the accessibility to, the main meteorological parameters which determine urban pollution levels, by comparing and contrasting methods in use in European countries, leading to recommendations for using routine meteorological information in air pollution assessments. The Action will address the best ways of providing data to the community of model users. The holders of meteorological information will be able to consider improved ways of processing meteorological information in order that it may be used effectively in air quality assessments of urban areas. Good methods for undertaking urban air quality assessments are required if the Directive on air quality assessment and management is to be implemented effectively. This Action 715 develops the scientific work achieved under the former Action COST-710 ("*Harmonization of the preprocessing of Meteorological data for atmospheric dispersion models* "; Fisher et al., 1998) from rural to urban conditions, and of Action COST CITAIR 615 ("*Data base, monitoring and modelling urban air pollution"*) for links between meteorology and urban air quality.

COST Action 715 is organised in four Working Groups, dealing with (1) urban wind fields, (2) surface energy budget and mixing height, (3) air pollution episodes in cities, and (4) meteorological input data for urban site studies. The members of working group 2 (WG2) are the authors of this contribution.

2. Lines of Activities of Working Group 2

Urban pollution meteorology is 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 COST-715, WG2 addresses the specific problems in describing the surface energy balance and the mixing height. The surface energy balance and the surface temperature and heat fluxes determine the hydrostatic stability conditions in the lower atmosphere and regulate its strength for mixing pollutants, the mixing height parameter determines the available volume for pollutants mixing.

From the outset, WG2 members decided to arrange their activities along the following lines:

k) To review theoretical concepts of the structure of the urban boundary layer.
l) To review and assess pre-processors, schemes and models for determining the mixing height, the surface energy budget and the stability that are available to the participants. Cases of strong stability and/or windless conditions are of special interest.
m) To review theoretical models together with available field measurements and LES for calculation of the minimum friction velocity and the heat transfer coefficient. Conditions of shear free convection over high roughness are of main importance
n) TTo identify and review suitable data sets within and outside the group that could be used to test and validate the pre-processors and models.
o) To carry out intercomparisons and to summarise comparisons of different schemes against each other and against data under specific conditions.
p) To assess the influence of the model outputs of certain specific effects such as complex topography, strong heterogeneity, slope effects and canopy trapping on radiative fluxes.
q) To assess the suitability of remote sensing tools to estimate canopy characteristics and surface fluxes.
r) To provide recommendations for the improvement of existing pre-processors and models and for the development of new schemes.
s) 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.
t) To promote co-ordination of related activities in Europe of presently scattered works, objectives, and responsibilities.

3. Status of activities

After 4 meetings the following progress against the background of the above-mentioned lines of activities was achieved by Working Group 2.

a) Some core widely-used pre-processors for the determination of the surface energy budget were identified and will be tested against three sets of data during this year. Some of the individual partners will test their own pre-processor against new data.
b) A preliminary list of data sets was established. It will be updated and, especially, WG2 will attempt to characterise these data sets for wider use.
c) Intercomparisons of different schemes are under planning.
d) New schemes are under development to take into account the specific features of urban surfaces and canopy.

4. WG2 specific COST studies

The performance of widely used boundary layer parameterisation schemes such as those of Holtslag and Van Ulden (1983) or Berkowicz and Prahm (1982) has not been tested in urban environments. Grimmond and Oke (2000) recently developed an urban pre-processor scheme LUMPS (Local-Scale Urban Meteorological Pre-Processing Scheme) which, similarly to the schemes mentioned above, requires standard meteorological observations, but additionally basic knowledge of the surface character of the target urban area. LUMPS was developed and tested for North-American cities, but not in Europe. A Study Contract proposal on the validation of net radiation and sensible heat flux parameterisations against measured data in three European cities was accepted by COST 715 and submitted to the COST Secretariat for approval. Using data from Birmingham (UK), Basle (CH) and Graz (A), a statistical comparison of modelled and measured net radiation and sensible heat flux time series will be undertaken. Based on the results, the performance as well as the applicability (with respect to data availability including land use and other surface descriptors) of the different schemes will be judged.

Another specific tool of COST, short-term scientific missions, were and will be conducted within Action 715 to exchange experience on certain pre-processors and data.

5. The Antwerp Expert Meeting

An expert meeting was arranged by WG2 to bring together experts to report on current understanding of the surface energy balance in urban areas and discuss future research needs. Eight presentations were given at Antwerp on 12 April 2000, consisting of both experimental and numerical contributions. **Mathias Rotach** discussed proper siting of urban meteorological instrumentation and summarised the requirements for meteorological instruments in urban studies with respect to the horizontal dimensions and the vertical structure of the urban boundary layer. Noting, from ground upwards, the canopy (between elements) as a part of the roughness sub-layer (up to 2 - 5 times the building height), the inertial sub-layer (flow is representative of a larger area of elements), with the urban mixed layer above, a common and overall accepted nomenclature is not available yet.

Sue Grimmond and Tim Oke reported on their measurement campaigns in several North American cities conducted over a ten-year period using tall towers with careful attention to fetch. They discussed in particular net all-wave radiation, latent and sensible heat flux, atmospheric stability, and storage heat flux. Sites are characterised by GIS using maps/photos/aerial photos/surveys of the area. The analysis of e.g. the latent heat fluxes shows big variations between the cities mainly as a function of the fraction of vegetation cover and the fraction of irrigated area.

Koen de Ridder assessed some pros and cons of remote sensing of the urban energy balance by satellite. He presented two methods to derive a map of the surface energy balance from satellite images, the first based on the difference between the surface radiation temperature measured by the satellite and the local air temperature, the second consisting in estimating surface parameters from satellite remote sensing and land-use maps and computing the surface energy balance via a SVAT (Soil Vegetation Atmosphere Transfer) module.

Valéry Masson carried out a numerical study using the meso-scale atmospheric model MESO-NH in combination with the Town Energy Budget (TEB) scheme to compute urban surface fluxes to investigate the influence of Paris on the atmospheric boundary layer for an anticyclonic summer day.

Tim Oke and Sue Grimmond compared conventional views of urban/rural differences for the surface energy balance on the basis of measurements undertaken in Sacramento, Tucson, and Vancouver. In Tucson and Sacramento which are semi-arid, the sensible heat flux at the rural site is bigger than at the urban site with a reversal of the traditional heat island effect.

Doug Middleton in collaboration with Nicola Ellis reported on field measurements of the surface fluxes at an industrial site in Birmingham, UK, and showed a box model with an urban heat storage adjustment to delay the onset of stable conditions on summer evenings.

Emmanuel Guilloteau used the French SUBMESO model which has a force-restore model of rural soil introducing new parameterisations for the urban soil-atmosphere interactions. The water parameters were tested in considerable detail. Many different soil types are represented. The test of the new urban soil model on five typical European quarters with imposed atmospheric data derived from the Hapex-Mobilhy experiment demonstrate the need to model the influence of the canopy vertical surfaces through radiative trapping and sensible heat storage.

Alberto Martilli parameterised heat and momentum fluxes in urban areas by taking into account roofs, walls, and the canyon floor, to be used by mesoscale models, tested for 2D idealised cases of an urban boundary layer.

An overview of the Antwerp presentations appeared in the EURASAP Newsletter 38 (Middleton et al., 2000). Extended abstracts of the presentations will be published as a COST-report (Piringer, ed., 2000).

The main conclusions and recommendations from the meeting were:

1. A number of European groups run mesoscale models with sub-models of fluxes for urban areas.

2. The influence of the urban canopy, building energy flows and thermal properties along with effective albedo reduction by radiative trapping between canyon walls may be important and should be modelled.
3. Water flux is a very important determinant of city heat island effects; the surrounding countryside must also be considered as it differs significantly from the remote 'rural' areas.
4. The behaviour of turbulent flux profiles in the thick roughness sub-layer due to high roughness elements requires more study, both in the field and with models.
5. Urban meteorological masts should go above the roughness sub-layer into the inertial sub-layer and above. The heights of these layers vary with conditions and fetch (2 to 5 times the building height).
6. Horizontal inhomogeneity of the canopy means diffusivities differ, $K_E \neq K_H$, since water transfers are surface processes while heat transfers are mediated by the canopy's own thermodynamics.
7. Sites should be characterised with the help of aerial photos, local surveys, maps, building dimensions, GIS, and urban data bases.
8. Satellites can measure some aspects of the urban environment, but are incomplete on their own and require skilled interpretation.

6. Forthcoming work

An experiment on the urban boundary layer (UBL) is being planned during the large French photochemistry experimental campaign ESCOMPTE (June-July 2001). The UBL-Escompte experiment is concerned with urban meteorology and remote sensing by satellite, encouraged by the Antwerp expert meeting discussions and recommendations. The WG2 members are keen to help in planning this experiment and to use its data for testing/validating the existing schemes and models. Another opportunity to stimulate forthcoming work of WG2 will be BUBBLE, the Basle Urban Boundary Layer Experiment, already accepted by the Swiss COST financial authorities, a joint action of six Swiss institutes, lead by Mathias Rotach. The urban boundary layer at Basle will be investigated by a one-year monitoring of near-surface turbulence characteristics as well as the UBL's vertical structure. A mesoscale numerical model will be used to validate and improve urban surface parameterisations.

A recent COST 715 Management Committee Meeting in Greenwich, UK, decided to support exchange amongst the working groups by planning and conducting joint workshops. In May 2001, in close co-operation with BUBBLE, WG1 and WG2 will conduct a workshop on boundary layer parameterisations at Zurich, followed by a common WG2 and WG3 workshop on mixing heights in urban areas, with special emphasis on peak pollution episodes, scheduled for autumn 2001 in Toulouse.

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