J1.1 EVALUATION OF AN URBAN SURFACE EXCHANGE PARAMTERIZATION FOR MESOSCALE MODELS

Alberto Martilli*,
CIEMAT, Madrid, Spain
Yves-Alain Roulet,
MeteoSwiss, Payerne, Switzerland
Clive Muller
Swiss Federal Institute of Technology, Lausanne, Switzerland

1. INTRODUCTION

The accuracy of air quality models has considerably increased in the last years, mainly because of two reasons:

- The increase of CPU power available, which has permitted higher resolutions, and the use of more complex and accurate physical, chemical and numerical schemes.
- A deeper scientific understanding of physical and chemical phenomena, in particular in urban areas, thanks to new and specific measurements campaigns. This new knowledge has been the fertile ground for new and more accurate parameterizations.

Models started to be extensively used for the evaluation of abatement strategies (Palacios et al., 2002), or for real time forecast (Delle Monache et al., 2005). As a consequence of these applications, new requirements started to be asked to air quality models. Among the others a more accurate characterization of pollutant concentration in urban areas at street level, the level where people live. This implies that the mesoscale meteorological models providing wind and turbulent fields to air quality models, need to resolve as good as possible features of the turbulence in the Urban Roughness Sublayer.

In this contribution, we will compare the results of an urban parameterization for mesoscale models (Martilli et al. 2002), run off-line, with data recorded during the BUBBLE campaign over the city of Basel (Switzerland). In this exercise not only surface fluxes, but also vertical profiles of the fluxes and mean variables will be compared.

2. BUBBLE

The Basel Urban Boundary Layer Experiment (BUBBLE) took place in Basel between August 2001 and July 2002. Its aim was to investigate the exchange processes near the urban surface, as well as the flow in the upper part of the urban boundary layer, using surface and remote sensing instrumentation. The most detailed set of observation was taken within and above a street canyon (Sperrstrasse), using a tower 30m high during the extensive period between 15 of June and 15 of July 2002. This site is located in the heavily built up part of the city, with a mean building height of 14 meters, and streets width of 14m as well (H/W=1). Wind and temperature were measured at different height in the tower (3.6, 11.3, 14.7, 17.9, 22.4 and 31.7 m above ground), and time averaged and vertical turbulent fluxes were provided for both variables.

3. MODEL SET UP.

As explained above, we are not interested only in the fluxes, but on the vertical structure of the Roughness Sublayer as well. For this reason, the turbulent diffusion equation is solved for 16 vertical levels with a regular resolution of 2 m (see full description in Roulet et al. 2005). Diffusion coefficients, and TKE are solved based on the scheme of Bougeault and Lacarrere (1989), modified to account for urban effects as in Martilli et al. (2002). All the horizontal gradients are neglected. The wind and temperature recorded at the highest point (30 m) were used as upper boundary condition for the 1-D model. Measured solar radiation was also used to force the model.

4. RESULTS

In order to give more elements to evaluate model results, a simulation with a “traditional” approach, meaning that only one very rough (z_o=1.5m) active surface is considered, was run in parallel. Although this traditional approach is strictly valid only in the inertial sublayer, it is still used in many applications as

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* *Corresponding author address:* Alberto Martilli, CIEMAT,Edificio 70, P1.5, Avenida Complutense 22, 28040 Madrid, Spain, tel. ++34-91 3466711, *e-mail*: alberto.martilli@ciemat.es.

representative of values at street level. In the following, this traditional approach is called '*trad*', while the full urban scheme is called '*urban*'.

4.1 Temperature

From the comparison between modeled and measured mean temperatures the following comments can be made (Roulet et al. 2005).

- Both model results (*urban* and *trad*), are able to reproduce mean temperature time series at 18m above street level (i.e. above roof height).
- At 3m above street level, within the urban canyon, *urban* is able to reproduce correctly the measured atmospheric cooling, while *trad* overestimates it.
- Measured mean temperature vertical profiles show a pronounced gradient at roof level during daytime. *Urban* can reproduce it, but in some situation it overestimates the mean temperature within the canyon (Fig. 1).

4.2 Turbulent heat fluxes.

Turbulent heat fluxes were also measured. It must be stressed here that within the Roughness Sublayer turbulent fluxes are not constant with height. In order to make a meaningful comparison, the modeled fluxes are computed directly from the turbulent scheme, following the *K* theory:

$$\overline{w'q'} = -K\frac{\partial q}{\partial z}$$

This is a comparison, then, not only of the surface exchange scheme, but also of the turbulent parameterization.

The following comments can be made (Roulet et al. 2005):

- During daytime at 18 m, *trad* largely overestimates measurements, while *urban* is much closer to data.
- During nighttime, 18 m measurements show a positive sensible heat flux, only partially reproduced by *urban.*
- At 3 m, *trad* fluxes are unrealistically very high, while *urban* and measurements are in the same range, but *urban* fails in reproducing the time behavior of the measurements.
- Vertical profiles are correctly reproduced in shape by *urban* during daytime (when *trad* fails), but during nighttime none of the models is able to reproduce the experimental behavior (Fig. 2).

In conclusion, the new scheme clearly shows that it can catch more physics than the traditional one, but it still fails to reproduce some important features, and improvements are needed.

From our point of view, the new work should be directed towards a more thorough validation, and the inclusion of more physical mechanisms in the scheme. In the following two sections this is briefly presented.

5. DISPERSIVE FLUXES

In a very spatially heterogeneous environment as the Roughness Sublayer, structures can form in specific locations (e. g. canyon vortex). It is necessary then, to distinguish between three components for the fluxes:

1. the mean flux.
2. the turbulent fluxes results of random, high frequency fluctuations.
3. the dispersive fluxes results of spatial structures forming in specific locations.

It is important to stress that over homogeneous surfaces the dispersive fluxes are negligible compared to the turbulent fluxes (as long as the time average period is long enough).

In order to compare the importance of the dispersive stress it is necessary to have measurements well distributed in space, which is in general not possible in real scale experiments. An alternative way is to run high resolution (e. g. building resolving) CFD models, validated against wind tunnel measurements. Such models can provide the spatial distribution needed to estimate dispersive fluxes (Martilli et al., 2006, in this conference). The idea then is to use CFD model results to validate and improve urban parameterizations.

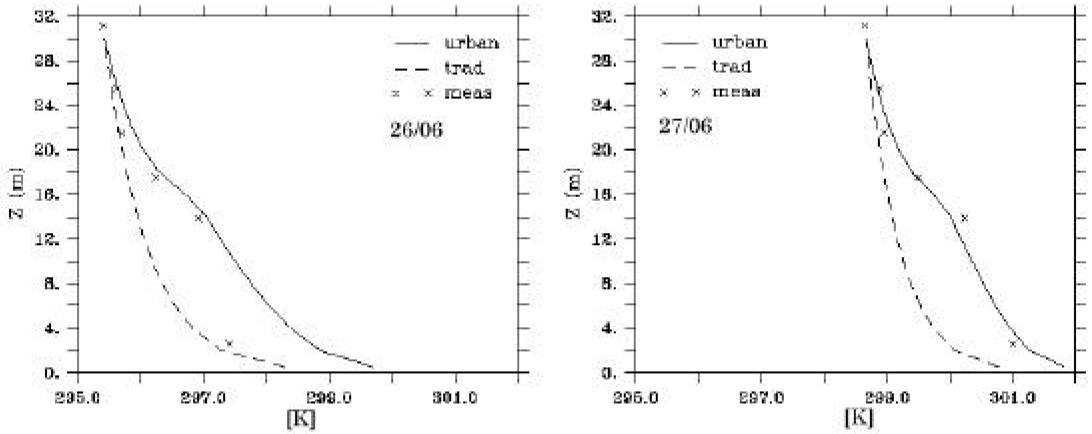

Figure 1. Vertical profiles of temperature during daytime for the 26 and 27 of June 2002.

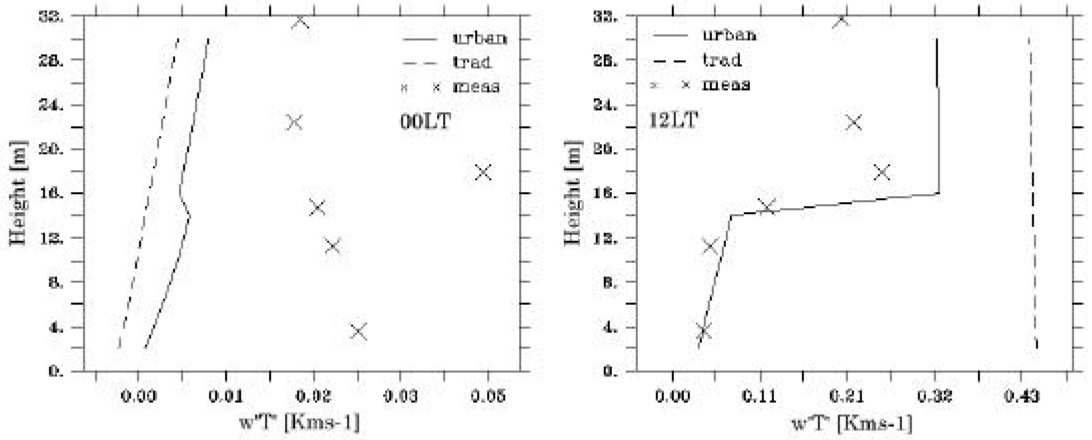

Figure. 2 Vertical profiles of turbulent heat fluxes for night (left) and day time (right).

6. BUILDING ENERGETICS

Another line of improvement of the parameterization is the introduction of a more accurate estimate of the heat exchanges between the interior and the exterior of the buildings.

As shown by a sensitivity analysis (Roulet 2004), in fact, model results are sensitive to the imposed internal building temperature in particular during night-time. We plan, then, to implement a building sub-module that accounts for:

1. Heat generation from equipment and occupants in the building
2. Air conditioning.
3. Natural ventilation.
4. Amount of radiation passing through windows.

This will make the scheme useful also for Urban Heat Island mitigation strategy studies.

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