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INTEGRATION OF URBAN EFFECTS IN A MESOSCALE DYNAMICAL MODEL OVER THE REGION OF BASEL (SWITZERLAND) AS A PART OF THE BUBBLE EXPERIMENT

Yves-Alain Roulet*
Swiss Federal Institute of Technology, Lausanne, Switzerland

1. INTRODUCTION

A city, by its caracteristical roughness height (z_0) and temperature evolution, has a strong impact on the structure of the Planetary Boundary Layer (PBL), and, hence, on the pollutant dispersion near the Earth surface. The involved processes can be induced by mechanical (turbulence induced by the buildings, where z_0 is heigher than for a rural landscape) or thermal (radiation trapping in the street canyons) effects. Due to the complexity of the atmospheric phenomena, mesoscale numerical models are the most appropriate tools to represent the flow field. Two scales are involved in this problematic : an urban scale of few kilometers, with particular "urban effects", and a meso-scale of few hundreds of kilometers representing the flow fields of the mesoscale circulation. The dynamical model must be able to represent these two scales in the most accurate way.

The aim of the BUBBLE (Basel Urban Boundary Layer Experiment) project, as a part of the COST action 715 - Meteorology applied to urban pollution problems, is to investigate the exchange processes near the surface, as well as the flow in the upper part of the Urban Boundary Layer (UBL), using surface and remote sensing instrumentation on one hand, and a mesoscale meteorological model on the other hand.

This contribution presents some preliminary results of the simulation over the Basel domain, using a mesoscale numerical model with an urban exchange parametrization in order to take into account the effects of the city on the mesoscale flow fields.

2. THE MODEL

The mesoscale model, FVM (Finite Volume Model), is anelastic non-hydrostatic and Boussinesq. The turbulence closure used in the model is k-l (Martilli, 2002). The parametrization of the surface exchange in urban areas (Martilli, 2002) considers the impact of the buildings on momentum, turbulent kinetic energy and temperature.

3. DOMAIN OF SIMULATION

The mesoscale model is applied over a domain of 192km x 240km centered over the city of Basel (see Fig. 1). It is planed to apply a forcing method (Charney et al., 1969) to the wind calculated by FVM by combining it with the wind calculated by the model used at the MeteoSwiss National Weather Service for the border and the top of the domain.

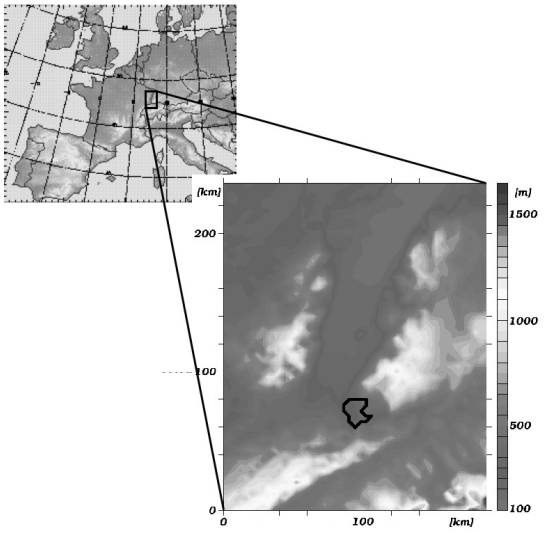

Fig. 1: The domain of the model used at the MeteoSwiss National Weather Service (top), and the domain defined for the BUBBLE project, with the location of the city of Basel (bottom).

4. RESULTS

The first simulations that have been carried out over the BUBBLE domain are pointing out the influence of the city on meteorological variables, such as the potential temperature or the wind speed. During the night, the simulation with the surface exchange parametrization for the urban areas shows smaller wind speed, from about 1.5 m/s, over the city than the simulation without the parametrization (see Fig. 2a). The potential temperature is higher in the first layers near the ground over the city with the parametrization (about 1.5°K during the night, see Fig. 2b, and 3.0°K during daytime, see Fig. 3b). The wind speed pattern during daytime over the city is also influenced by the parametrization (see Fig. 3a). The flow is beeing accelerated upwind from the city (wind is blowing from left to right on the picture) in the lower part of the PBL, and it decelerates downwind, while this pattern is inversed in the upper part of the PBL.

* Corresponding author address : Yves-Alain Roulet, Air and Soil Pollution Laboratory, Swiss Federal Institute of Technology, 1015 Lausanne, Switzerland ; e-mail : yves-alain.roulet@epfl.ch

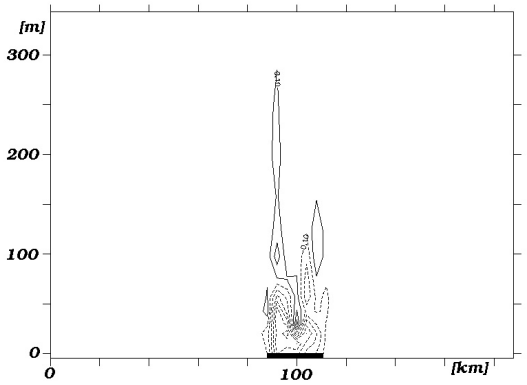

Fig. 2a : Wind speed differences between a simulation with the surface exchange parametrization for urban areas and a simulation without. Nighttime situation ; dashed lines indicate locations where the wind speed is smaller with the parametrization.

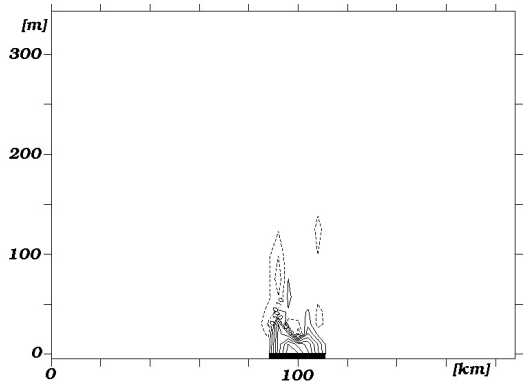

Fig. 2b : Potential temperature differences between a simulation with the surface exchange parametrization for urban areas and a simulation without. Nighttime situation ; solid lines indicate locations where the potential temperature is higher with the parametrization.

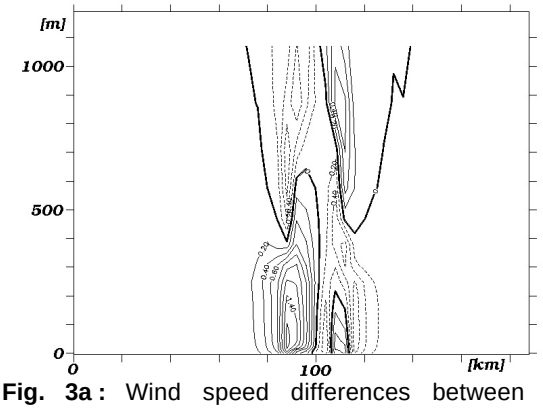

Fig. 3a : Wind speed differences between a simulation with the surface exchange parametrization for urban areas and a simulation without. Daytime situation.

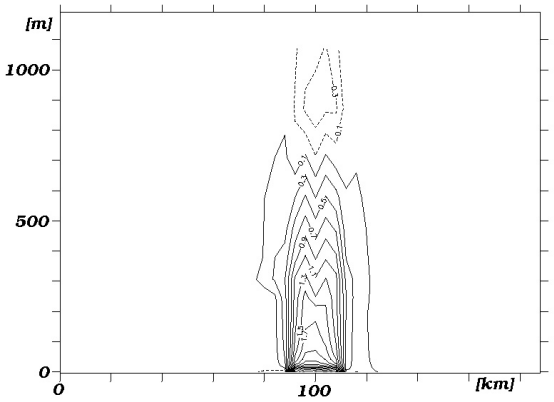

Fig. 3b : Potential temperature differences between a simulation with the surface exchange parametrization for urban areas and a simulation without. Daytime situation.

5. PERSPECTIVE

The next steps concerning the modelling part of the BUBBLE project will be to insert the forcing method using simulation results from the MeteoSwiss National Weather Service model, to carry out several simulations over the city of Basel in order to analyse the sensitivity of crucial parameters of the surface exchange parametrization. Further on, simulations over a smaller domain representing the city with a thinner resolution should be done, using the simulation results of the larger domain as input.

References

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