11.3 URBAN CANOPY MODELING INFLUENCE ON URBAN BOUNDARY LAYER SIMULATION

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1. Introduction

In order to determine the heat fluxes at the urban canopy-atmosphere interface for conditioning the lower boundary of atmospheric models, an urban soil model SM2-U has been developed (Dupont, 2001). SM2-U has been coupled with the French atmospheric model SUBMESO to simulate the Urban Boundary Layer (UBL) at high spatial resolution.

This presentation presents the first results of a sensitivity study to evaluate the influence of the urban canopy representation in the UBL simulations.

2. Urban soil model SM2-U

SM2-U represents an extension to urban surfaces of the Force-Restore model ISBA (Noilhan & Planton, 1989). It has thus the advantage to be altogether a rural and urban soil model. Its purpose is not to detail the physical processes inside the Urban Canopy (UC) but to parameterize the "surface" heat fluxes used by atmospheric models.

The aerodynamic characteristics of the urban surfaces are represented by an apparent ground where the obstacles are modeled by a roughness length and a displacement height.

SM2-U considers 5 cover modes (Fig. 1 a): natural soil, a mixture between vegetation and bare soil; bare soil; artificial surface, with or without vegetation; buildings roofs; and water surfaces. Three soil layers are considered: a surface layer for non urban surfaces, a second soil layer corresponding to the influence zone of the vegetation roots, and a third soil layer used as a water reservoir providing water to the second soil layer by diffusion during dry periods.

In a computational cell, the model determines an aerodynamic surface temperature and a surface specific humidity for each cover mode by solving heat and water budget equations. Then an average is obtained on each cell by weighting with the surface cover rate of each mode.

The UC influence is modeled in the artificial surface heat budget equation (i) by introducing the additional heat storage of buildings walls and (ii) by accounting for radiation trapping through a street canyon effective albedo parameterization constructed from the work of Masson (2000) (Fig. 1 b). Thus, the temperature of the artificial surface cover mode corresponds to an average over all street surfaces.

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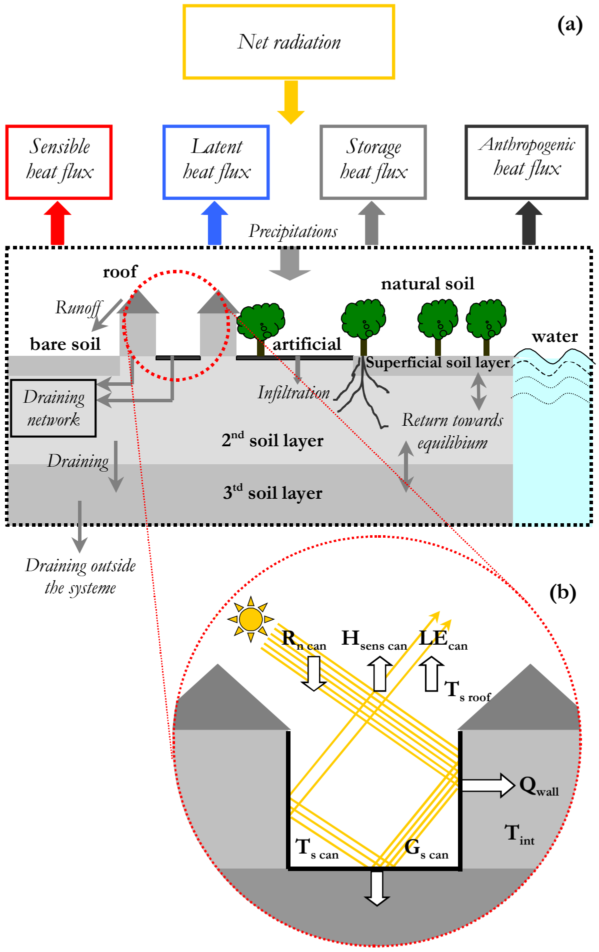

Fig. 1: Scheme of SM2-U.

Before its coupling with SUBMESO, SM2-U has been successfully tested in 3 configurations with a weather forcing without feedback between ground and atmosphere: i) a validation of SM2-U new rural part against the HAPEX-MOBILHY and EFEDA experimental data ; ii) a comparison between the moisture fluxes of SM2-U and an urban hydrological model, EHU, against the measurements recorded at an urban catchment (Berthier et al., 2001); and iii) a sensitivity study of SM2-U on five European urban quarters (Dupont et al., 2000).

3. Results

The coupling of SUBMESO and SM2-U is tested above an hypothetic city, with a flat ground and an infinite lateral extension (i.e., periodic boundary conditions). Simulations are carried out on a diurnal cycle starting at midnight. Dynamics and thermodynamics inside the computational domain are forced only by the ground fluxes. Three simulations are compared. In the first one, the city is composed of 4 quarters: residential, high rise buildings, city center, and industrial-commercial. In the second simulation, the city is represented by a single quarter averaging the four preceding quarters. In the third simulation, the urban surfaces of the first simulation are replaced by a dry bare soil.

The first simulation shows the formation during the day of convective cells downstream the urban zone, and the generation of an heat island with a maximum during the evening (Fig. 2 a).

The two other simulations demonstrate the interest of detailing the thermodynamics of the urban area even for regional scale simulations.

When the city is replaced by one average quarter, an attenuation of the heat island is observed in the evening (Fig. 2 b), as well as a reduction in the convective cells intensity due to the gumming of city heterogeneities, and the smoothing of heat fluxes at the canopy-atmosphere interface.

When the city is replaced by a dry rural soil, during the day the UBL thermodynamics is rather similar to that obtained in the first simulation, but in the evening the behavior becomes quite different because the heat storage and release are not represented by this simplified city (Fig. 2 c). It thus appears difficult to represent an urban area by using the soil model rural part only.

4 Conclusion

These first UBL simulations with SM2-U coupled to SUBMESO demonstrates the importance of detailing the city thermodynamics in UBL high resolution simulations.

5 References

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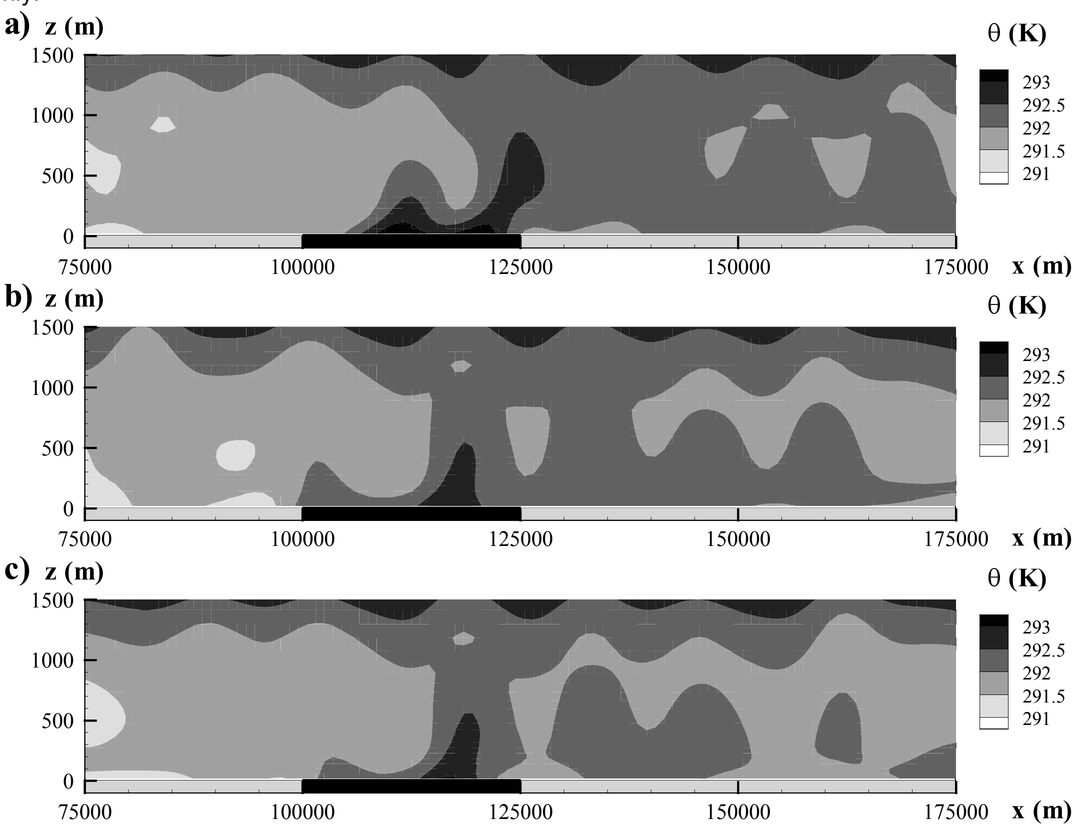

Fig. 2: Potential temperature field θ at 6 p.m. above the city (black rectangle) represented by a succession of 4 urban quarters (a), by an average urban quarter (b) and by a dry rural soil (c)