# Inclusion of an urban canopy parameterization in the Canadian meteorological models

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## 1. Introduction

The current meteorological models can be run at high horizontal resolutions reaching a few hundreds of meters. At such scales, the cities cover several grid points and the impact of the urban radiative, energetic, dynamic and hydrological effects must be taken into account in the computation of the surface exchanges. Specific urban canopy schemes have been recently developed in order to parameterize the exchanges between the urban covers and the atmosphere and implemented in atmospheric mesoscale models, e.g. the models of Mills (1997) and Martilli et al. (2002). The Town Energy Balance scheme (TEB) (Masson, 2000) is part of this new generation of models. It is already coupled to the French community research atmospheric model Meso-NH (Lafore et al., 1998) and was recently included in the physics package of the Global Environmental Multiscale (GEM) and the Mesoscale Compressible Community (MC2) Canadian models.

## 2. Presentation of TEB

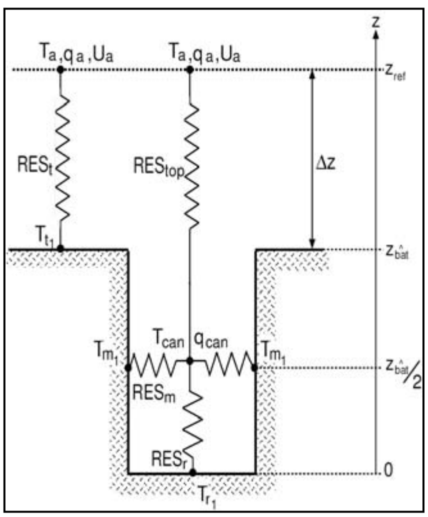


*Figure 1: The TEB urban surface scheme.*

TEB is an urban canopy model based on the concept of urban canyon (Nunez and Oke, 1977). At each mesh of the model is associated one single street canyon composed of three simple elements, namely one horizontal road, two identical vertical walls and one roof (Figure 1). The canyon is described by a set of input data: geometric parameters (mean building height, dynamical roughness length of the urban canopy, building density, aspect ratio of the street and ratio between the vertical surfaces and the plane built area) and radiative and thermal properties of materials (albedos, emissivities, heat capacities and thermal conductivities) for each of the surfaces. Thus, this canyon corresponds to an average of all the streets of the grid mesh. TEB applies two major assumptions: (1) the orientation of the streets is isotropic; and (2) the intersections are neglected. Given the fact that the microscale effects are different for each urban surface, TEB computes the radiative, energetic and water exchanges independently for the road, the walls and the roof.

Finally, by using a simplified but realistic description of the urban geometry, TEB is especially well adapted to mesoscale modeling. It was already evaluated in offline mode on various kinds of urban sites (Masson et al., 2002; Lemonsu et al., 2004) and applied to 3D modelling exercises (Lemonsu and Masson, 2002; Lemonsu et al., 2005).

## 3. Implementation of TEB

Initially, the physics package of GEM and MC2 decomposes the surface as 4 distinct types of covers: land surfaces with vegetation, open waters, ice-covered waters and glaciers. Each of them is treated by a specific parameterization. The implementation of TEB in the physics package required the inclusion of a fifth type of cover associated with the built-up areas. Most of the input data describing the urban canyons are determined according to the land use cover classification (next section). The prognostic variables such as surface temperatures, air temperature and humidity inside the canyons are initialized by using analyses or forecasts. At each grid point, the surface outputs are

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aggregated according to the fraction of each type of covers, especially the energy and momentum fluxes which are required to force the atmospheric model. To evaluate the impact of the urban parameterization on the response of the atmospheric model, simple meteorological situations of the Joint Urban 2003 experiment (Oklahoma City, US) will be simulated with MC2 and TEB.

| Urban classes | | | |
|---|---|---|---|
| 1 | High Buildings | 7 | Roads and parking lots |
| 2 | Mid-high buildings | 8 | Road borders |
| 3 | Low buildings | 9 | Dense residential |
| 4 | Very low buildings | 10 | Mid-dense residential |
| 5 | Industrial areas | 11 | Low-dense residential |
| 6 | Sparse buildings | 12 | Mix of nature and built |

*Table 1: Identification of the 12 urban classes*.

As for the soil-vegetation-atmosphere transfer (SVAT) models, the TEB input data are associated with a land use cover classification. Since most of the databases do not include urban classes, a general methodology has been developed to produce urban classifications in a semi-automatic way for the major North American cities. It is based on the pre-analysis of digital elevation models (DEM) and of ASTER satellite imagery providing a classification in simple elements (i.e. road, roof, tree etc) at 15-m horizontal resolution. Afterwards, an aggregation process and a decision tree classification lead to a 60-m database of 12 urban classes (Table 1). The sets of parameters associated with each class are defined from the analysis of aerial photograph samplings and the use of literature tables and previous study results (Masson et al., 2003). A first classification was established for Oklahoma City.


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