The Urban Climate Model TEB: Recent developments and CO2 modelling

V. Masson, A. Lemonsu, C. de Munck, R. Schoetter, G. Pigeon, E. Redon, M. Goret

METEO-France CNRS

Motivations

- Cities weather and climate is governed by physical and geobiological processes strongly modified compared to the countryside, but also by social and economic processes.
- TEB has been built to simulate the impact of cities, including the **Urban Heat Island** (UHI) in NWP and climate models.

A simplified geometry

The 3D city simplified as an urban canyon:

- Road, roof, 2 walls
- Morphological parameters (height, aspect ratio, land cover,…) **in each grid cell**

With many processes

Needed to represent the urban climate:
- 3D in-canopy radiative exchanges
- Urban vegetation
- Snow, water, energy fluxes
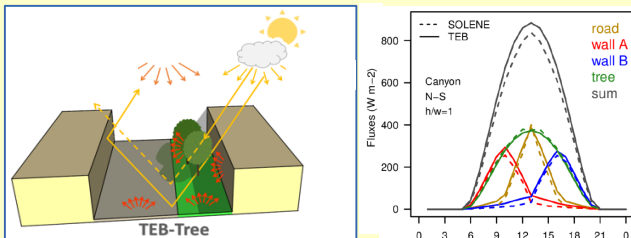- Heat storage in construction materials

Figure: left: TEB canyon geometry,
right: validation of solar exchanges (with SOLENE model)

Building Energy Consumption

A building energy module is included in TEB which allows to take into account:

- Energy balance of the interior of buildings
- Architecture, windows, ventilation, …
- Multiple uses (offices, residential, …)
- Human behaviour !
- **Energy demand** by cooling and heating
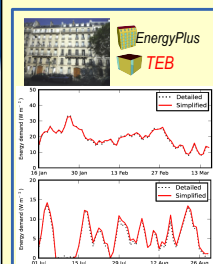
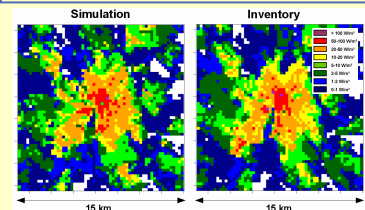Winter Heating flux, Toulouse

Figure: validation of energy consumptions in TEB
Left : against Energy+   Right: against inventory

TEB simulates the 2-way interactions between building energy and the UHI.

Weather-interactive CO2 emissions

- Building's energy demand → CO2 emissions
- Urban vegetation photosynthesis and respiration

This allows to simulate the **variations of the urban CO2 emissions** at the time-step of the model.

TEB simulates C02 fluxes

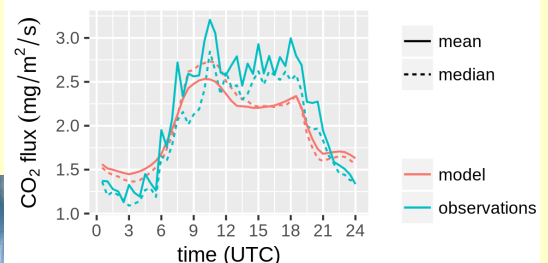Mean CO2 diurnal cycle, winter 2005

Figure : Validation of TEB CO2 emissions against CO2 flux tower (CAPITOUL experiment, Toulouse)

TEB in the operational NWP models
TEB represents the cities in the HIRLAM/ALADIN consortium models, as well as in GEM operated by the Canadian Weather Service.

Years of interdisciplinarity

References :
- *Model main structure : Masson 2000, BLM; Lemonsu et al 2004, JAM; Lemonsu et al 2010, JAMC*
- *Vegetation: Lemonsu et al 2012, GMD; de Munck et al 2013, GMD; Redon et al 2017, GMD*
- *Building Energy Module & CO2: Bueno et al 2012, GMD; Pigeon et al 2014, EB;*
  Schoetter et al 2017, GMD; Tornay et al 2017, UC; Goret et al 2018