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# Enhanced software and platform for the Town Energy Balance (TEB) model

D. Meyer<sup>1, 2</sup>, R. Schoetter<sup>3</sup>, V. Masson<sup>3</sup>, and S. Grimmond<sup>1</sup>

<sup>1</sup> Department of Meteorology, University of Reading, Reading, UK <sup>2</sup> Department of Civil and Environmental Engineering, Imperial College London, London, UK <sup>3</sup> CNRM UMR 3589, Université Fédérale de Toulouse, Météo-France/CNRS, Toulouse, France

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## Software

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## Summary

The Town Energy Balance (TEB) model (Masson, 2000) is a physically based single layer Urban Canopy Model (UCM) to calculate the urban surface energy balance at neighborhood scale assuming a simplified canyon geometry. It includes several capabilities (Table 1) that have been extensively evaluated offline with flux observations (Lemonsu, Grimmond, & Masson, 2004; Leroyer, Mailhot, Bélair, Lemonsu, & Strachan, 2010; Masson, Grimmond, & Oke, 2002; Pigeon, Moscicki, Voogt, & Masson, 2008) and online coupled to atmospheric models such as ALARO (Gerard, Piriou, Brožková, Geleyn, & Banciu, 2009) in ALARO-TEB (Hamdi, Degrauwe, & Termonia, 2012), the Global Environmental Multiscale (GEM; Côté et al. (1998)) in GEM-TEB (Lemonsu, Belair, & Mailhot, 2009), Meso-NH (Lac et al., 2018; Lafore et al., 1998) in TEB-MesoNH (Lemonsu & Masson, 2002), the Regional Atmospheric Modeling System (RAMS; Pielke et al. (1992)) in RAMS-TEB (Freitas, Rozoff, Cotton, & Dias, 2007), the Advanced Regional Prediction System (ARPS; Xue et al., (2000)) in ARPS-TEB (Rozoff, Cotton, & Adegoke, 2003), and the Weather Research and Forecasting (WRF; Skamarock et al. (2019)) in WRF-TEB (Meyer et al., 2020).

Here, we present an enhanced software and platform for the TEB model to help scientists and practitioners wishing to use the TEB model in their research as a standalone software application or as a library in their own software. This includes several features such as cross-platform support for Windows, Linux, and macOS using CMake (Kitware Inc., 2020), static and dynamic library generation for integration with other software/models, namelist-based configuration, integration with MinimalDX (Meyer & Raustad, 2019) and PsychoLib (Meyer & Thevenard, 2019) to improve the modelling of air conditioners (AC) and psychrometric calculations respectively, a thin interface used in the coupling with WRF-CMake (Riechert & Meyer, 2019), helper functions for Python for pre- and post-processing inputs and outputs files, and a tutorial in Jupyter Notebook to allow users to quickly become familiar with the general TEB modeling workflow. In the new platform we implement testing at every code commit through continuous integration (CI) and automate the generation of documentation. The project is developed as a free, open source, community-driven project on GitHub (<https://github.com/teb-model/teb>) to support existing and new model applications with enhanced functionality. We welcome contributions and encourage users to provide feedback, bug reports and feature requests, via GitHub's issue system at <https://github.com/teb-model/teb/issues>.

**Table 1:** Main capabilities available in the Town Energy Balance (TEB) model (Masson, 2000). The number of features available in TEB has increased since its first version published in 2000. (\*) Capability not currently available in the TEB software.

Modeling capability	Reference
Urban Surface Energy Balance and Snow Building Energy Model (BEM)	Masson (2000)
In-canyon urban vegetation and variable road orientation	Bueno et al. (2012), Pigeon et al. (2014)
Green roofs, irrigation of green roofs, gardens and watering of roads	Lemonsu et al. (2012)
Solar panels for hot water and/or photo-voltaic (PV)	de Munck et al. (2013)
Human behavior related to building energy consumption*	Masson et al. (2014)
Calculation of urban carbon dioxide fluxes*	Schoetter et al. (2017)
Urban trees*	Goret et al. (2019)
	Redon et al. (2017; 2020)

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