Sensitivity of a hydro-climatic model to land use data

Context

Urbanisation has increased significantly since the second half of the 20th century and will continue in the coming decades, both globally and in France (United Nations, 2019). By the soil sealing and the use of heat-storing materials, urbanisation modifies both the water cycle and the energy balance of surfaces, causing flooding, wastewater discharges and urban heat islands (Fletcher et al., 2013; Grimmond, 2007). Climate change could further exacerbate these effects. Nature-based solutions (NBS) are increasingly being promoted as solutions for adapting to climate change. Because they are accompanied by the de-sealing of urban surfaces, they promote an increase in evapotranspiration and infiltration into the soil, bringing the water balance closer to the to the water balance of the natural environment. Evapotranspiration, via the flow of latent heat, also allows to improve the energy balance by cooling the air, and complements the shading effects of trees. Many NBS are thus multifunctional: they can have an impact on various issues including water management, thermal comfort in addition to the well-being and quality of life of the inhabitants and the energy consumption of buildings.

With regard to stormwater management and thermal comfort, NBS need to be evaluated: hydro-climatic numerical tools can be relevant. The Gustave Eiffel University (Water and Environment Laboratory) is participating in the development of a research tool (TEB, Stavropulos-Laffaille et al., 2018; Stavropulos-Laffaille et al., 2020) that coherently and homogeneously couples water and energy balances and has parameterizations adapted to vegetation (Lemonsu et al, 2012; de Munck et al, 2013; Redon et al, 2017; Bernard, 2021; Tunqui-Neira, et al, 2022), thus enabling the evaluation of this type of design solution. This model needs various input data, including fine-scale land use. A methodology (Betou et al, 2022) has been developed to define the land cover of a metropolis according to 5 types of land cover (vegetation, building, road, bare soil, roadway) from freely available databases. It allows both to define a type of land use when several types coexist and to define one when the available data are not precise enough. As the methodology is source of uncertainties, it is necessary to estimate the impact on the variables simulated by the model.

Objective and content of the internship

The objective of the internship is to carry out a sensitivity analysis of the hydro-climatic model TEB to land use data. It is organised in 3 stages.

A first phase of bibliography will focus on the hydro-climatic model TEB, on the input parameters related to urban vegetation (tree height, crown width, type of vegetation, etc.), the databases used and the analysis methods, in particular the criteria for comparing data sets (Stavropulos-Laffaille et al., 2018), as well as previous studies on the sensitivity of the models to the data.

In a second phase, the candidate will build the land cover datasets to feed the TEB model. For this, he/she will have to develop a methodology to define these different data sets. The main data to be studied will be those related to vegetation (high or low, bare soil, LAI). The aim will be to identify the areas of uncertainty on each parameter (input to the model).

The third phase will consist of conducting a sensitivity analysis of the model to land cover data. The candidate will analyse the results of the different simulations by identifying the relevant model output variables and determining evaluation criteria.

Bibliographic references

de Munck C, Lemonsu A, Bouzouidja R, Masson V, and Claverie R. 2013. The GREENROOF module (v7.3) for modelling green roof hydrological and energetic performances within TEB. Geoscientific Model Development 6, 1941–1960. DOI: 10.5194/gmd-6-1941-2013

Fletcher, T.; Andrieu, H. & Hamel, P., 2013. Understanding, management and modelling of urban hydrology and its consequences for receiving waters: A state of the art Advances in Water Resources , 51, 261 – 279.

Grimmond, S., 2007. Urbanization and global environmental change: local effects of urban warming Geographical Journal, Blackwell Publishing Ltd, 173, 83-88.

Lemonsu A, Masson V, Shashua-Bar L, Erell E and Pearlmutter D. 2012. Inclusion of vegetation in the Town Energy Balance model for modelling urban green areas. Geoscientific Model Development 5, 1377–1393. DOI: 10.5194/gmd-5-1377-2012

Redon, E. C.; Lemonsu, A.; Masson, V.; Morille, B. & Musy, M., 2017. Implementation of street trees within the solar radiative exchange parameterization of TEB in SURFEX v8.0 Geoscientific Model Development,10, 385-411.

Stavropulos-Laffaille, X.; Chancibault, K.; Brun, J.-M.; Lemonsu, A.; Masson, V.; Boone, A. & Andrieu, H., 2018. Improvements to the hydrological processes of the Town Energy Balance model (TEB-Veg, SURFEX v7.3) for urban modelling and impact assessment Geoscientific Model Development, 11, 4175-4194

Stavropulos-Laffaille, X., 2019. Pour une analyse des impacts du changement climatique sur l'hydrologie urbaine : Modélisation hydro-microclimatique de deux bassins versants expérimentaux de l'agglomération nantaise. ED Sciences pour l'Ingénieur, Centrale Nantes - Université Bretagne Loire

Skills required

The candidate in Master II or final year of engineering school should have a background in climatology or urban hydrology or in cartography. Knowledge of GIS and R would be an asset.

To apply : send a cover letter, CV and grades from the current or previous year to Katia Chancibault katia.chancibault@univ-eiffel.fr, and Florian Betou florian.betou@univ-eiffel.fr

Duration of the internship : 5 to 6 months from February 2023

Internship location : Université Gustave Eiffel, Nantes campus, Route des ponts et chaussées, Bouguenais.

Gratuity : approximately 600 €/month (the gratuity is calculated on the basis of a daily amount at the legal rate in force).