Post-doc offer

Combination of green and grey solutions to adapt cities to climate change

Scientific and operational context:

Due to the intensification of weather extremes related to climate change and the waterproofing of surfaces resulting from urbanization, rainwater management and heat island mitigation are now more than ever a key issue for urban planners. The renaturation of cities (by implementing green roofs and walls, trees, rain garden…) appears to be a measure of resilience to mitigate these effects. These green solutions (also named Nature-based Solutions) contribute to manage precipitation at the source and to locally cool the air. They can also be coupled with engineering (grey) solutions to optimize their performances (by storing water to supply evapotranspiration for instance). Therefor the constrained urban environment promotes the development of combined green and grey solutions to be implemented where it is possible (on roads or on roofs for instance). Many works are currently underway to optimize the operation of these infrastructures and make them as efficient as possible.

Objective:

In this context, this Post-Doc position aims to study the relevancy and performances of combined green and grey solutions for urban planning in present and future climate. It is particularly focused on the following targeted issues: managing stormwater and flooding, and mitigating heat islands. It will adopt a multi-scale modelling framework to consider the complexity of the urban environment and thermos-hydric processes across spatial and temporal scales.

Work plan:

1- *Thermo-hydric modelling of small green and grey solutions*:

The objective is to propose a physically-based modeling module capable of simulating the thermo-hydric behavior of green and grey solutions in present and future climate. This model should take into account both soil heterogeneity and climate scenarios variability. Special attention will be paid to model evapotranspiration and infiltration processes using local geotechnical data and taken into account the extreme values of the climate-related hazards (intense rain, extreme heat). To achieve this, it is proposed to use multifractal-based tools. The latter have been widely used to characterize and simulate geophysical fields exhibiting extreme variability over wide range of scales such as rainfall or hydraulic conductivity (Schertzer and Tchiguirinskaia, 2020). They were also used recently to model granular structure and both distribution and evolution of water fluxes in an artificial media (Ramanathan et al., 2023). In a first step the model will be tested and validated by using experimental data produced on Pilot Sites. Secondly, it will be carried out on climate scenarios to design the most relevant solutions for rainwater management and cooling objectives.

2- *Modelling of adaptation solutions at the urban scales*:

This second part will focus on some urban areas prone to flooding. It aims to reproduce their current hydrological behaviour and to simulate the impact of green and grey solutions to mitigate this flooding risk in a context of climate change. For this purpose, the Multi-Hydro platform (Qiu et al., 2021) will be carried out. It is a distributed model able to take into account the spatial heterogeneity of the urban environment. The possibility of integrating the previously developed module will be considered. It is also expected to deepen the coupling between the Multi-Hydro and Solène-Microclimat models carried out within the framework of the ANR EVNATURB project. Applied at the development project scale, this coupled model simulates the water and energy balances of the surface, and thus makes it possible the assessment of green solutions in heat islands mitigating. Beyond an improvement of the numerical scheme, an evaluation protocol will be implemented to ensure the proper functioning of the coupling, and to validate its outputs using experimental data. Applied on the same urban areas, this coupled model will make it possible to asses the impact of the studied adaptation solutions on the urban microclimate in the same context of climate change.

Profile of the candidate:

Doctor in Hydrology or Environmental Physics, or Engineer from a high school (professional experience would be appreciate) interested in multiscale modelling, experimental monitoring and industrial applications.

The host-lab

The Hydrology, Meteorology and Complexity laboratory of the Ecole des Ponts ParisTech (HM&Co-ENPC) has been developing for several years research activities around the renaturation of the urban environment, and more particularly the implementation of green roofs (European Project Blue Green Dream, ANR project EVNATURB, Life ARTISAN). With a long experience in multiscale observation, understanding, and modelling of the water cycle, HM&Co is interested in the quantitative evaluation of the ecosystem performances provided by this revegetation, and more particularly in the thermo-hydric aspects for questions for rainwater management and urban cooling.

Administrative elements:

This 12-month contract (with a possibility of renewal) will take place at the Hydrology, Meteorology and Complexity laboratory of the Ecole des Ponts ParisTech in Champs-sur-Marne (France, 20 minutes from Paris). Remuneration according to skills. Starting October-November 2024.

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References

Qiu, Y., da Silva Rocha Paz, I., Chen, F., Versini, P.-A., Schertzer D, Tchiguirinskaia I., 2021. Space variability of hydrological responses of Nature-Based Solutions and the resulting uncertainty, *Hydrology and Earth System Sciences* (Scopus, CS=9,5), 25(6), 3137-3162. https://doi.org/10.5194/hess-25-3137-2021

Ramanathan, A., Versini, P., Schertzer, D., Perrin, R., Sindt, L., & Tchiguirinskaia, I., 2023. A universal multifractal-based method to model pore size distribution, water retention and hydraulic conductivity of granular green roof substrates, *Geoderma*, *438*, 116640: https://doi.org/10.1016/j.geoderma.2023.116640

Schertzer, D. and Tchiguirinskaia, I., 2020. A century of turbulent cascades and the emergence of multifractal operators. Earth and Space Science, 7 (3). https://doi.org/10.1029/2019EA000608