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 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: mitigating heat islands, managing stormwater and flooding, and achieving a net gain in biodiversity. It will adopt a multi-scale framework to consider the complexity of the urban environment and thermos-hydric processes across spatial and temporal scales.

Work plan:
This study will be based on a complementary Monitoring / Modelling approach.

1- *Thermo-hydric Monitoring*.

This first part will consist of developing protocols for measuring water and energy (thermal) balances on vegetated and/or artificialized surfaces as varied as possible. To do this, it will be necessary to implement networks of heterogeneous and low-cost environmental measurement sensors. The diversity and complementarity of these sensors will make it possible to better quantify the spatial and temporal variabilities of the fields and flows involved in the thermo-hydric processes of this type of structure (precipitation, temperature, radiation, infiltration, evapotranspiration, etc.). For more mineral surfaces (e.g. permeable concrete capable of retaining water), the heterogeneity of the porous medium could be specifically studied to characterize on the one hand the granular structure, and on the other hand the distribution and evolution of water content. These monitoring protocols will be implemented on specific Pilot Sites including green and grey solutions prototypes. These protocols could be inspired from similar campaigns that were carried out on a 1-hectare green roof located in the ENPC campus (see Versini et al., 2020, 2023).

2- *Development of innovative technical solutions "0 emission"*:

The objective is to propose a physically-based model capable of simulating the thermo-hydric behavior of these 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 the Pilot Sites. Secondly, it will be carried out on climate scenarios to design the most relevant solutions for rainwater management and cooling objectives.

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 May 2024.

Contact: pierre-antoine.versini@enpc.fr (+33 (0)1 64 15 37 54)

References

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

Versini, P.-A., Castellanos, L.A., Ramier, D., and Tchiguirinskaia I., 2023. Evapotranspiration evaluation by 3 different protocols on a large green roof in the greater Paris area, *Earth Syst. Sci. Data*, https://doi.org/10.5194/essd-2023-324

Versini, P.-A., Stanic, F., Gires, A., Schertzer, D., and Tchiguirinskaia, I., 2020. Measurements of the water balance components of a large green roof in the greater Paris area, *Earth Syst. Sci. Data*, 12, 1025–1035, https://doi.org/10.5194/essd-12-1025-2020