PhD Proposal

Nature-based Solutions for Mitigating Urban Heat Islands: High-Resolution Monitoring and Characterization of Thermal Fluxes

Scientific context:

Urban areas are confronting various challenges due to unsustainable urbanisation, the degradation of natural capital, and the anticipated increase in the intensity and frequency of extreme weather events driven by climate change. One consequence is urban heat islands (UHIs), characterised by localised elevated temperatures. To mitigate UHIs, Nature-based Solutions (NbS)—such as green roofs, vegetated swales, or rain gardens—are theoretically effective, as vegetation-driven evapotranspiration can help cool the air.

Objectives:

To explore the potential contribution of NbS in mitigating UHIs, this proposed PhD project aims to measure and analyse the thermo-hydrological behaviour, with a particular focus on evapotranspiration flux (latent heat flux). The key objectives of this research are (i) to develop monitoring strategies for measuring evapotranspiration flux with the highest possible precision and (ii) to characterise the spatiotemporal variability of evapotranspiration across a wide range of scales.

Work plan:

These experiments will be conducted on various Nature-based Solutions (NbS) implemented in urban areas. For instance, the large-scale monitoring of the Green Wave at the ENPC Campus will continue. The PhD student will specifically develop a monitoring protocol for implementing a scintillometer, which is particularly suited for measuring sensible heat flux. Combined with other sensors (radiometer, thermocouples…), this will allow for the latent heat flux estimation at high resolutions. These measurements will be complemented by local experiments using a portable transpiration chamber and an IRGASON, an instrument used to measure wind speeds and CO2 and H2O concentrations.

Multifractal-based tools will be applied to the collected data to characterise the space-time variability of the measured fluxes and address non-stationary challenges. Additionally, these tools will be used to generate and reproduce phenomena at different scales, both larger and smaller. This approach enables statistical physics to study complex phenomena, particularly through stochastic simulations of geophysical fields based on their scaling laws. As a result, it becomes possible to describe and simulate the variability of intermittency beyond the mean field, and to study its extremes.

Profile of the candidate:

The candidate should have graduated in fluid mechanics or environmental physics, have capabilities in computer simulations, and be of interest for the experimental follow-up.

Administrative part:

This 3-year PhD will be hosted from the Hydrology, Meteorology and Complexity laboratory at Ecole Nationale des Ponts et Chaussées (HM&Co/ENPC, 6-8 avenue Blaise Pascal, 77455 Champs-sur-Marne, France). A secondment is also planned at the Polytechnic University of Madrid (Spain). It will be carried out under the supervision of:

- Pierre-Antoine VERSINI (HM&Co, ENPC), researcher in urban hydrology and NbS for climate change adaptation

- Ana TARQUIS (CEIGRAM, Universidad Politécnica de Madrid), professor in agro-environmental modelling and monitoring (multi-scale analysis)

The PhD position should start in Autumn 2025.

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References:

Versini, P.-A., Castellanos, L.A., Ramier, D., and Tchiguirinskaia I., 2023. Evapotranspiration was evaluated using three protocols on an extensive green roof in the greater Paris area, *Earth Syst. Sci. Data*, https://doi.org/10.5194/essd-2023-324

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