INSTITUT POLYTECHNIQUE DE PARIS

RESEARCH DAY

Researcher Biographies and Project Abstracts

Symposium
“Water and Environment”

December, 1st
4.00 pm to 6.00
Lecture hall 4

Chaired by
Philippe Ciblat, Professor at LTCI,
a laboratory of Télécom Paris

Pierre-Antoine Versini is a Research Director at the Hydrology, Meteorology, and Complexity Laboratory of the École Nationale des Ponts et Chaussées (HM&Co-ENPC). His work focuses on adapting cities and territories to the consequences of climate change, primarily addressing issues related to hydrology, microclimate, and biodiversity. For over a decade, he has participated in and developed research programs centered on leveraging Nature-Based Solutions to tackle these challenges through an interdisciplinary, multi-physics, and multi-scale approach. This includes projects such as ANR EVNATURB (2018-2022), LIFE ARTISAN (2019-2027), and ANR PENATE (2025-2029). Since 2024, he has also served as the scientific lead for the Fresnel multi-scale geophysical observation platform in the Île-de-France region, developed at ENPC. This platform integrates innovative scientific equipment and advances in hydrological modeling, including the Multi-Hydro model and multifractal techniques.

Numerical Modeling of Urban Water and Environment: Nature-Based Solutions for Climate Adaptation

Urban areas are increasingly exposed to the compounded effects of climate change, including the intensification of extreme rainfall and heat events. Numerical modeling provides a powerful framework to assess and design adaptation strategies, particularly through the implementation of nature-based solutions (NbS). This talk addresses recent advances in thermo-hydric modeling across urban scales, emphasizing the representation and performance evaluation of NbS as components of integrated urban water management systems.

A key aspect of this work concerns the spatio-temporal variability of precipitation and its implications for hydrological modeling in heterogeneous urban catchments. The presentation also explores methods for representing vegetation dynamics, either through functional trait-based modeling or explicit biophysical process representations, to better capture plant–water–energy interactions within NbS.

A part of these studies will be illustrated through the use of the Multi-Hydro platform and its coupling with Solene-Microclimat, which together enable the simulation of thermo-hydrological processes in urban environments. These models have been developed and validated using experimental datasets, ensuring process robustness and predictive reliability across scales.

The results presented stem from ongoing research conducted at the HM&Co laboratory (Hydrology, Meteorology and Complexity), developed through participation in various national and European research projects. A multi-scale analytical framework is introduced to support the design and optimization of NbS deployment under regulatory and operational constraints. This integrated approach bridges process-based modeling with practical implementation, advancing the quantitative assessment of NbS as effective tools for urban climate resilience.

Marie-Christine Gromaire is a top grade researcher at École Nationale des Ponts et Chaussées (France), within Leesu laboratory. She develops pluridisciplinary research on water and contaminant flows associated with urban runoff and their fate in the urban system, mainly developed as part of OPUR Observatory of Urban Hydrology in Paris. In recent years, she focused on hydrological and physico-chemical processes within nature-based urban runoff management structures, the resilience of such facilities, as well as the modelling of their large-scale deployment.

Modeling the ecological transition of urban stormwater management

Urban stormwater management is undergoing a profound transformation driven by the need to reconcile hydraulic performance, climate resilience, and ecological preservation. This ecological transition seeks to shift from conventional drainage systems toward more sustainable source control solutions that provide hydrological control, improve water quality, restore water resources and enhance urban ecosystems. Nature Based Solutions such as green roofs, raingardens, swales, infiltration basins or urban wetlands are especially promoted for a more nature like urban water cycle.

Modelling plays a central role in understanding and optimizing this transition. It enables the evaluation, planning, and optimization of sustainable stormwater practices across multiple spatial and temporal scales. Research lead at ENPC/Leesu couples field monitoring, lab work and physical based or conceptual modelling of hydrological and reactive transport processes within Sustainable Urban Drainage Systems (SUDS) to analyse both water balance and pollutant dynamics.

A specific focus is put on a better quantification of infiltration, soil storage, evapotranspiration and exfiltration fluxes to improve SUDS design in the case of unfavourable underground conditions. Modelling the adsorption/desorption and biodegradation of micropollutants within the soil or engineered porous media of SUDS allows for the assessment of potential risks to groundwater or ecosystems posed by micropollutants emitted into the runoff from construction materials or traffic. Accounting for the uncertainties related to climate change, urban heterogeneity or the complexity of biophysical systems is a major challenge in these developments.

At the city scale, modelling needs to extend beyond individual SUDS performance to assess their cumulative and systemic effects. Ongoing work aims at the construction of large-scale deployment scenarios of SUDS and their modelling with the TEB hydro-climatic model, in which a SUDS module has been co-developed.

Remi Carmigniani is a researcher in fluid mechanics at the ENPC's Saint-Venant Hydraulics Laboratory, Rémi, who is passionate about swimming, participated in the Sciences2024 research program. He contributed to the STHP NePTUNE project and to the modeling of race conditions for events in the Seine. In this work, he combines physical modeling, numerical simulation, experimental measurements, and computer vision to help athletes optimize their performance.

Swimming in the Seine

The Alexandre III Bridge will remain one of the iconic images of the Paris 2024 Games. It hosted the open water swimming events: marathon swimming and triathlon. In open water, conditions are inherently uncertain: temperature, currents, and water quality can influence the course of races, or even whether they take place at all. By combining field measurements, forecasts, and modeling, we provided the French teams with data that enabled them to optimize their strategies and turn these uncertainties into potential assets for their performance. In this presentation, we will focus on the water quality indicator developed for the French teams and on our ongoing research into water quality in urban rivers such as the Seine, which are prone to contamination mainly due to wastewater discharge after heavy rainfall. A methodology is proposed at two time scales, to implement early warning forecasts and assess changes in water quality over the years.

Cédric Tard obtained his M.Sc. from Université Paris Saclay in 2002. He completed his Ph.D. at the John Innes Centre (University of East Anglia, UK) under Prof. Chris Pickett, investigating molecular models of [FeFe]-hydrogenase. After postdoctoral research on luminescent molecular clusters with Prof. Jean-Pierre Boilot at École Polytechnique and on proton-coupled electron transfer with Prof. Jean-Michel Savéant at Université Paris-Diderot, he joined the CNRS as an Associate Research Scientist in 2009. Since 2017, he has been a Professor at École Polytechnique and, since 2020, has been the director of the Laboratoire de Chimie Moléculaire. His research bridges fundamental electrochemistry and catalytic systems, with a focus on sustainable energy solutions, most recently advancing seawater usage for CO_2 extraction and electrolysis for green hydrogen production.

CO_2 Extraction from Seawater: from Lab Bench to Ocean Depths

This presentation explores innovative technologies for extracting carbon dioxide from aqueous media, focusing on electrochemical methods and techniques that redistribute and dilute acidity from the surface ocean to deeper layers. These approaches aim to reduce surface acidification and accelerate carbonate homeostasis, addressing the critical issue of ocean acidification and its impact on marine wildlife. Key technologies discussed include advanced electrochemical processes and novel methods for acidity redistribution, each with its unique advantages and challenges. Specific case studies will be presented to illustrate the real-world applications and effectiveness of these technologies. The main challenges, such as sustainability, energy consumption, or salinity, will be addressed, along with potential solutions to overcome these obstacles. The potential impacts of these technologies are significant, including a reduction in ocean acidification and an increase in the ocean's capacity to act as a carbon sink, thereby mitigating atmospheric carbon dioxide concentrations. By highlighting these cutting-edge methods and their practical implementations, this talk aims to inspire further research and adoption of these technologies to protect our oceans and combat climate change.

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