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Learning from the past to shape the future. Harnessing multi-scale human data and earth observations to foster sustainable water usage and societal adaptation to climate change

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Human-water feedbacks have been increasingly studied in the last decades, motivating the foundation of new disciplines such as socio-hydrology and, in general, enhanced interest toward conceptualization and modelling of the spatial and temporal dynamics of human-water systems. With anthropogenic activities being widely recognized as a major driver of global change and the human population being increasingly exposed to hydroclimatic extreme events, human systems are now at the forefront of the water cycle. Yet, human preferences, behaviors, and decisions in relation to water systems - including water usage dynamics, adoption of precautionary measures against climate extremes, and adaptation of urban landscapes - are often modelled based on behavioral or economic theories, or derived from small-scale samples. This often leads to heterogeneous results, which are often case-specific, or lack validation against real-world observations.

The availability of increasingly fine-resolution data from distributed sensors and databases (e.g., water consumption data from intelligent meters, flood insurance adoption records at the household level, and socio-demographic data) and earth observations (e.g., aerial and satellite imagery) provides us with an empirical basis to model heterogeneous individual and societal behavioral patterns, along with their determinants.

In my research, I strive to develop multi-disciplinary data-driven behavioral modelling approaches that bridge hydrologic/hydraulic sciences, informatics, economics, and systems engineering and harness information from multi-scale human data and earth observations and the power of data analytics and machine learning to better understand, model, and characterize human behaviors in coupled human-water systems. In this talk, I will first provide an overview of recent advances in descriptive behavioral modelling in human-water systems, with a focus on household-to-continental scale modelling of residential water consumption patterns and adoption of household flood insurance. Second, I will elaborate on modelling challenges that are motivating ongoing research related to machine learning-based behavioral models, including model explainability, data and computational requirements, generalization and scalability, and the influence of data resolution in time and space. Finally, I will discuss how developing descriptive models that learn human behaviors retrospectively can be used to inform forecasting tasks and formulate policy-

relevant recommendations to shape future societal adaptation to climate change. Implications span from informing the design of feedback-based digital user engagement in pursuit of water conservation, to fostering proactive climate adaptation, addressing societal inequalities and heterogeneous water access and affordability conditions, or evaluating incentive programs and policies for sustainable urban development.