KEYNOTE LECTURE: Characterization and monitoring of the riparian and hyporheic zones

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The hyporheic and riparian zones (HRZ) are the areas located beneath and adjacent to rivers and streams, where the interactions between surface water and groundwater take place. This complex physical domain allows the transport of several substances (e.g., water, nutrients, and pollution) from a stream to the unconfined aquifer below, and vice versa, thus playing a fundamental role in the river ecosystems. The importance of the HRZ makes its characterization a goal shared by several disciplines, which range from hydraulics and ecology to biogeochemistry. Regardless of the field of study, the main aim is always to completely describe the structures and the processes that distinguish this zone. Furthermore, flow and transport models are nowadays key instruments to efficiently characterize the HRZ, given their ability of simulating surface water-groundwater exchange phenomena at a local scale. In order to achieve these common goals, many disciplines use invasive techniques that permit punctual *in situ* surveys and/or sample analysis. Point measurements may be precise, but their capability to sample in space and time with sufficient resolution to avoid aliasing is very questionable. The resulting picture of the real processes is thus, often, strongly biased. There is no doubt that non-invasive techniques can play a major role in this research area. Electrical Resistivity Tomography (ERT) has been applied in cross-well configuration or with a superficial electrodes deployment. Distributed Temperature Sensing (DTS) usage in hydro-geophysics has been developing since the last decade, revealing a wide applicability to the typical issues of this field of study. In this work, we present the general challenges concerning the hydro-geophysical characterization of the HRZ, and the case study of the Vermigliana Creek in the Northern Italian Alps, where a combination of ERT and DTS apparatuses has been installed below the river bed, and time-lapse measurements over several seasons as well as short-term response measurements help cast light on the surface water-ground water interactions.