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Modelling subsurface hydrology in Mediterranean regions to investigate spatial and temporal trends

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Mediterranean environments have highly variable hydrologic regimes characterised by two distinct seasons: cold/wet and warm/dry. Understanding how this climate is expressed in subsurface hydrology is a basis for the effective management of water as a resource. Riparian systems are particularly complex due to the contribution of both infiltrating precipitation and subsurface hyporheic flows. Therefore a more in-depth investigation of subsurface hydrology is required to understand riparian corridors.

Numerical models can be used to simulate soil-water distribution and exchange. We have built-on existing theory of flow through porous media to create a physically-based, river- and climate-driven numerical model of hyporheic flow and infiltration/evaporation that predicts the water content at any depth in a soil column and at any distance from the river channel. The model incorporates the Richards equation - describing the vertical infiltration and diffusion of water in porous media - and the Boussinesq equation, which simulates the horizontal evolution of the water-table (hyporheic flow). These equations have been fully coupled to reflect the interplay between the saturated and unsaturated zones. The model produces a daily time-series of water table elevations and vertical soil moisture patterns in the vadose zones to allow us to study the hydrological partitioning and soil-moisture distribution in a given soil profile.

We apply this tool to Mediterranean regions over a number of years to explore seasonal and inter-annual hydrological patterns. Two sites along the Rhône River in France with distinct climates allow us to investigate the impact of riverine and climate functioning. In particular we assess the impact of distance from the river channel and exposure to warmer and dryer conditions. Finally, the temporal legacy of extreme events such as floods and droughts is considered within the context of the impact to riparian vegetation. These comparisons will resolve the hydrologic contribution of each environmental variable to develop a better understanding of the whole subsurface system.