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Process-based hydrological modeling by integrating pedology, geophysics and soil hydrology

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The precise spatio-temporal estimation of subsurface hydrological states and water fluxes is still a challenge in hydrology, because most hydrological processes are highly nonlinear and controlled by time-varying boundary conditions. Hence, numerical models are required for their comprehensive representation. Another challenge is that soils are spatially heterogeneous and the identification and accurate spatial representation of such heterogeneity is still an area of intensive research in the field of hydrogeophysics. To date, there are only very few approaches that combine all the available information from classical pedological soil characterization, hydrological monitoring, geophysical subsurface characterization and state-of the art hydrological modeling to achieve a comprehensive estimation of hydrological states and fluxes.

The primary objective of this project is to apply an integrated approach for improved process-based soil hydrological modeling of hillslope-scale vadose zone water fluxes. The approach builds on the integration of classical pedological expertise for soil characterization, on accurate monitoring of soil water content as well as on state-of-the-art time-lapse geophysical measurements for the characterization of subsurface heterogeneity. It finally integrates the gathered information into a physically-based numerical model that is capable of simulating soil water fluxes including saturated and unsaturated water flow, surface runoff, soil evaporation, plant water uptake, snow accumulation and melt with high spatial and temporal resolution.

The project will expand the suite of approaches currently available for estimating soil water fluxes towards a new dimension as the combination offers the opportunity to maximize the potentials of available measurement and modeling techniques and to minimize the sources of uncertainty in the predicted states and fluxes. It will provide important knowledge needed for transferring this approach to larger scales where accurate quantification of soil water fluxes at the farm or catchment scale is required for a more efficient water and nutrient management in the context of sustainable food production and climate change.