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Development of a neural network to calculate groundwater recharge in karstified aquifers

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Groundwater resources are expected to be affected by climate change and population growth and thus sophisticated water resources management strategies are of importance especially in arid and semi-arid regions. A better understanding of groundwater recharge and infiltration processes will allow us to consider not only water availability but also the sustainable yield of karst aquifers.

Because of the thin or frequently absent soil cover and thick vadose zones the assessment of groundwater recharge in fractured rock aquifers is highly complex. Furthermore, in (semi)-arid regions, precipitation is highly variable in space and time and frequently characterized by data scarcity. Therefore, classical methods are often not directly applicable.

This is especially the case for karstic aquifers, where i) the surface is characterized by depressions and dry valleys, ii) the vadose zone by complex infiltration processes, and iii) the saturated zone by high hydraulic conductivity and low storage capacity. Furthermore, epikarst systems display their own hydraulic dynamics affecting spatial and temporal distribution of infiltration rates. The superposition of all these hydraulic effects and characteristics of all compartments generates a complex groundwater recharge input signal.

Artificial neural networks (ANN) have the advantage, that they do not require knowledge about the underlying physical processes or the structure of the system, nor do they need prior hydrogeological information and therefore no model parameters, usually difficult to obtain. Groundwater recharge shows a high dependency on precipitation history and therefore the ANN to be chosen should be capable to reproduce some memory effects. This is considered by a standard multilayer perceptron (MLP) ANN, which uses a time frame as an input signal, as well as a recurrent ANN. For both large data sets are desirable. Because of the delay between input (precipitation, temperature, pumping) and output (spring discharge) signals, the data have to be analyzed in a geostatistical framework to determine the time lag between the input and the corresponding output as well as the input time frame for the MLP.

Two models are set up, one for the Lez catchment, located in the South of France, and one for the catchment of the Gallusquelle spring, located in South-West Germany. Both catchments aquifers

are characterized by different degrees of karstification. While in the Lez catchment flow is dominated by conduit network, the Gallusquelle aquifer shows a lower degree of karstification with a stronger influence of the aquifer matrix. Additionally, the two climates differ, with the Lez catchment displaying a Mediterranean type of climate while the Gallusquelle catchment is characterized by oceanic to continental climatic conditions.

Our goal is to find neural network architecture(s) capable of reproducing the general system behaviour of the two karst aquifers possibly transferable to other karst systems. Therefore, the networks will be trained for the two different locations and compared to analyze similarities and differences.