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Integrating field and numerical modeling methods for applied urban karst hydrogeology

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Abstract. Infrastructures constructed on unstable geologic formations are prone to subsidence. Data have been collected in the context of an upgrading project for a highway located beside a river dam constructed on gypsum-bearing formations. Surface water infiltrates upstream of the dam, circulates through the gravel deposits and into the weathered bedrock around and beneath the dam, and exfiltrates downstream into the river. As a result, an extended weathering zone within the bedrock and preferential flow paths within voids and conduits developed as part of a rapidly evolving karst system. Enhanced karstification in the soluble units of the gypsum-bearing formations resulted in subsidence of the dam and the highway.

Since 2006, changes in the groundwater flow regime have been investigated by different methods that allowed the evaluation of the long-term performance of the infrastructures. Geological (outcrops, lithostratigraphic information from boreholes), hydrometrical (extensive groundwater monitoring, dye tracer tests) and hydrogeophysical (Electrical Resistivity Tomography, ERT) data were integrated into high-resolution 3-D hydrogeological and 2-D karst evolution models. The applied methods are validated and the sensitivity of relevant parameters governing the processes determined.

It could be demonstrated that the applied methods for karst aquifer characterization complement each other. Short-term impacts and long-term developments on system-dynamics and the flow regime could be evaluated. This includes the description of the transient character of the flow regime during and after episodic flood events (surface-groundwater interaction, conduit and diffuse model outflow) as well as the evaluation of time scales for karst evolution. Results allow the optimization of investigation methods for similar subsidence problems, ranging from general measurements and monitoring technologies to tools with predictive utility.

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