Geophysical Research Abstracts
Vol. 16, EGU2014-7550, 2014
EGU General Assembly 2014

Inferring thresholds in karst aquifers from spring responses: the example of the Lurbach karst system (Austria)

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Threshold behavior in hydrological systems generally involves a qualitative change of a single process, the system response or the functioning of the system. Different types of thresholds and their underlying controls are examined using the example of the Lurbach karst system (Austria). This karst system receives concentrated allogenic recharge from the sinking stream Lurbach, which under low-flow conditions only resurges at the Hammerbach spring. Under medium- to high-flow conditions, however, an overflow toward another spring, the Schmelzbach outlet occurs. The overflow probably is activated when a conduit pathway connecting the two sub-catchments is flooded at a given threshold water level. Unfortunately, the value of this threshold cannot be determined, as information about water levels within this karst system are scarce due to the lack of observation wells and the inaccessibility of relevant cave sections. Yet a corresponding threshold discharge of the Hammerbach spring can be inferred from tracer test results. Interestingly, a tracer test conducted in 2008 suggests that the overflow is activated at a discharge lower than that inferred from tracer tests reported earlier (Wagner et al., EGU2011-7962). In order to better understand this suspected change in the discharge threshold, the physicochemical responses of the Hammerbach spring were analyzed. Applying the concept of process time scales (Birk and Wagner, EGU2013-11365) to the Hammerbach spring suggests that the threshold travel time controlling the response of the spring water temperature was changed in the time period from 2006 to 2009 relative to the years before. At the same time, the Hammerbach spring hydrograph appears to have changed. For instance, the flow duration curve and the master recession curves for the time period from 2006 to 2009 are found to be markedly different from those of earlier time periods. All of these observations can be consistently explained by a reduction of the conduit diameters within the Hammerbach sub-catchment, presumably caused by the redistribution of sediments due to a distinct flood event in 2005. This finding suggests that a change in the hydrological functioning of the Lurbach karst system occurred possibly because a threshold related to sediment transport was crossed. Whether or not such thresholds are crossed depends on processes and factors both internal and external to the karst aquifer. In the case considered here, the suspected redistribution of sediments, for instance, is likely controlled by geomorphologic processes within both the karst aquifer and the headwater catchment providing the allogenic recharge as well as by anthropogenic and climatic factors affecting the occurrence of extreme hydrological events. Identifying and understanding such controls is of paramount importance for assessing the uncertainty of model predictions in karst catchments.