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Quantifying the regional groundwater/surface water interaction based on 18O and Deuterium

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Small, non-permanent ponds of glaciofluvial origin, called cattle holes, are widely spread in the younger Pleistocene landscapes of the northern hemisphere. New investigations show that much more of the kettle holes in NE Germany are more closely connected to the groundwater than expected. Thus kettle holes reflect a free groundwater surface at the interface between the aquifer and the topography. They are not isolated hydrological depressions and can be viewed as linked components of a hydrologic continuum. Therefore, these kettle holes have a high informative value regarding changing behavior of the regional groundwater system functioning as a suitable indicator for changes of a regionally connected hydrological system. The unsolved challenge of this approach is the complexity and high abundance of kettle holes which requires an elaborate hydrological monitoring of a large number of small lakes.

Therefore, an alternative approach was used to record the dynamic behavior of the hydrological system. Measurements of the stable isotopes 18O and Deuterium enables the quantitative estimation of the individual water flux and evapotranspiration rates. An isotope-mass-balance model was used to quantify lake water balances during a one year sampling period. The approach after Skrzypek et al. 2015 based on the global relationship between the d18O and dD values of the precipitation – described by the Global Meteoric Water Line (GMWL) and the kinetic isotopic fractionation during evaporation which leads to a deviation from the GMWL indicated by a decrease of the slope of this relationship. Assuming that the lake is hydrostatically connected to the groundwater the applied isotope mass-balance model accounts for the quantification of the evapotranspiration rate considering the groundwater inflow compensating the evaporation loss. Due to the low effort of isotopic sampling, the isotopic monitoring of a large number of kettle holes is possible, even regarding a longer period of time. First results clearly show distinct patterns of the temporal dynamics of the groundwater/surface water interaction reflecting the regional system behavior. They provide the basis for anticipating future development of the hydraulic system under climate change, and – regarding system changes - for adapted water resources management decisions.