Resilience of the Alsatian aquifer, France to climate and anthropogenic change: A case study of the Grand Ried

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The vulnerability of the Alsatian aquifer to climate change and water abstraction has hardly been investigated whilst climate change impacts such as decreasing snowfall, droughts and heat waves are becoming stronger and water abstraction for irrigation is seasonally intensifying as a result. Despite being influenced by a European temperate climate, seasonal drying up of groundwater-fed streams has been recently observed in the region of the Grand Ried of the Middle Alsatian Plain and drought decrees in Alsace have intensified. The Alsatian aquifer, an alluvial aquifer located on the French side of the Upper Rhine, belongs to one of the largest aquifers in Europe. It not only provides drinking water to approximately 1.5 million inhabitants but is also a highly important water supply for industry and agriculture. This study aims to improve our understanding of the interactions between groundwater levels of the Alsatian aquifer and river discharge during drought periods. Lying within the Upper Rhine Graben, this complex basin is flanked by the Vosges and Black Forest mountains to the West and East respectively. As such, the aquifer is influenced by both the River Rhine, its main tributaries and the Vosges mountains. At present, it is difficult to differentiate climate and anthropogenic signals in groundwater level lowering during the summer. In this study, spatial and temporal correlations of river discharge and groundwater levels were analysed based on meteorological and hydrological data available since 1955 from national and regional agencies and will form the base for hydrogeological modelling in the next phase. High resolution field data enables to capture complex interactions and for this purpose an intensive interdisciplinary field study was carried out in the summer. Water levels of 7 groundwater-fed streams, including 3 springs, were recorded automatically at hourly time steps and accompanied by manual measurements of temperature, dissolved oxygen and turbidity as well as biological observations. Streams show subdaily water level variations mainly due to evapotranspiration and water withdrawals for irrigation. Even though irrigation represents on average only 18.5% of annual groundwater abstraction in the Alsace region over a territory that is 50% agricultural, water withdrawals are concentrated over a few months in summer and their impacts are visible. Climate change has decreased snow storage and snow water equivalent as well as increased periods without precipitation and thereby increased evapotranspiration over the last decades. The challenge is to determine whether irrigation effects are stronger than evapotranspiration which would imply that water abstraction impact could outweigh that of climate change during summer droughts. Because they can affect the sustainability of drinking
water supply, biodiversity and economic activities, awareness on droughts impacts and water abstraction should be increased.