Climate change effects on groundwater recharge and temperatures - status and development for Swiss aquifers

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Climate change will have both quantitative and qualitative effects on groundwater resources. These impacts differ for aquifers in solid and unconsolidated rock, urban or rural locations and the principal processes of groundwater recharge.
Knowledge of the intrinsic key parameters (aquifer geometries, storage properties, groundwater renewal rates, residence times, etc.) and the principal groundwater recharge processes as well as temperature imprinting enables a comparison and forecast of the sensitivity of individual aquifers to climate change.
The sensitivity of future groundwater temperature development for selected climate projections was investigated for representative Swiss unconsolidated rock groundwater resources on the Central Plateau, the Jura and the Alpine region.
For non-urban and rural areas, climate change is expected to have a strong overall impact on groundwater temperatures. In urban areas, however, direct anthropogenic influences are likely to dominate. Increased thermal subsurface use and waste heat from underground structures as well as adaptation strategies to mitigate global warming result in increased groundwater temperatures. Likewise, measurements for the city of Basel show that groundwater temperatures increased by an average of 3.0 ± 0.7 °C in the period from 1993 to 2016 and can exceed 18 °C, especially in densely urbanized areas. Similarly, regarding shallow aquifers with low groundwater saturated zone thicknesses, such as in Davos (Canton Grisons), groundwater temperatures will strongly be influenced by changes in groundwater recharge regimes. In contrast, groundwater temperature changes within deep aquifers with large groundwater saturated zone thicknesses, such as in Biel (Canton Bern), or in some cases with large distances from the surface to the groundwater table and extended unsaturated zones, e.g. in Winterthur (Canton Zurich), are strongly attenuated and can only be expected over long time periods.
We show that seasonal shifts in groundwater recharge processes could be an important factor for the future development of groundwater temperatures. Moreover, the interaction with surface waters and increased groundwater recharge during high runoff periods are likely to have a strong influence on groundwater temperatures. Accordingly, a shift in precipitation and river flood events from summer to winter months is accompanied by an increase in

groundwater recharge in comparatively cool seasons, which would be accompanied by a tendency for “cooling” groundwater.

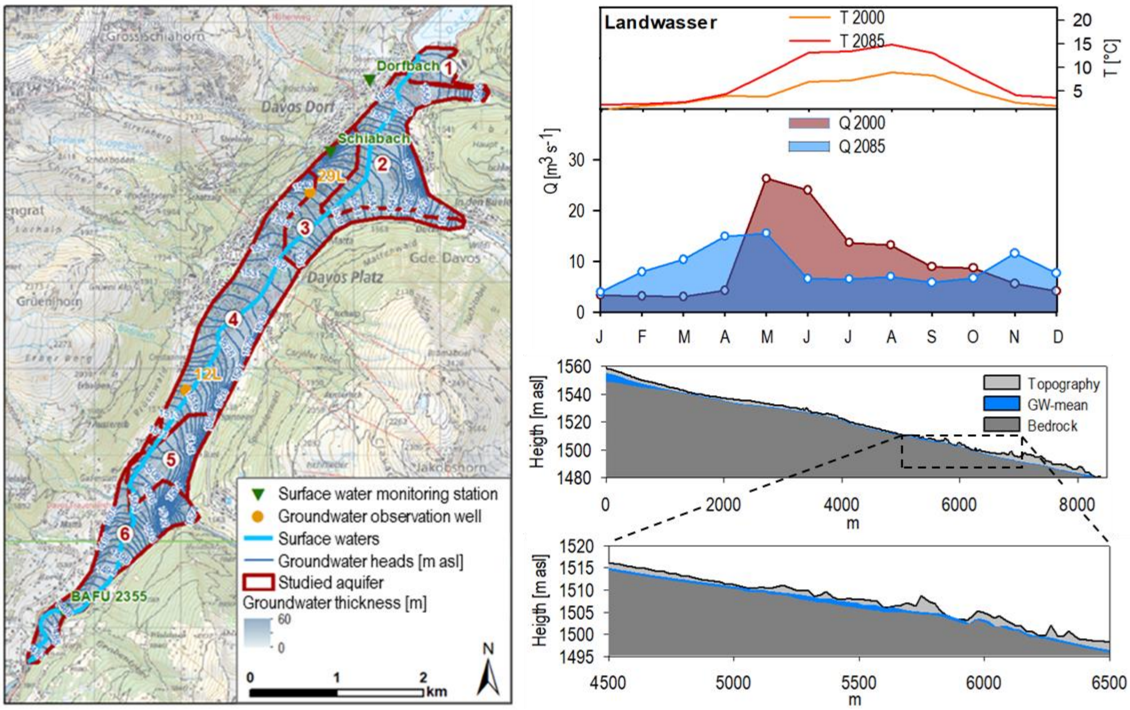

Figure 1. Left: Aquifer of Davos (Canton Grisons) illustrating groundwater head and thickness, including groundwater and surface water monitoring stations; for 6 subdomains groundwater flow length and times were evaluated. Upper right: Simulated emission scenario RCP85 and results for river discharge (Q) and temperature (T) for the reference state 2000 and for the year 2085. Lower right: Progression of the river Landwasser related to the bedrock and the surface topography for a mean groundwater head situation, including a zoom of the river section between 4500 and 6500 m where the river locally can be in contact with the groundwater table.