Impact of extreme events and changing environmental conditions on groundwater recharge

Main Supervisor: **Steffen Birk** [**showcase 1**]
Research field "Meteorology and hydrology: Groundwater resources in climate change"
Research question 2 | Cluster 1
Links to showcases Foelsche 1, Foelsche 2, Kirchengast 1, Kirchengast 2, Maraun 1, Steiner 2

Background: Current hydrological models frequently rely on simplifying approaches for calculating evapotranspiration such as correlations between evapotranspiration rates and air temperature. If the environmental conditions change strongly these approaches are subject to high uncertainty, first because of the impact of climate parameters other than temperature, and second because of changes in the soil-vegetation system. For instance, it has been suggested that the increasing carbon dioxide content of the air has reduced the transpiration by plants ("physiological forcing") and thus caused globally increasing continental runoff during the last decades despite the rising air temperatures (Gedney et al., 2006). This leads to the following research question: How is evapotranspiration and hence groundwater recharge affected by climate change taking into account changes in hydrological extremes and the responses of the soil-vegetation system to changing environmental conditions?

Goal: This thesis aims, first, to identify how groundwater level and discharge responded to extreme events in the past; second, to provide a quantitative understanding of the recharge mechanisms underlying the observed responses; and third, to assess potential impacts of future changes in the soil-vegetation system on evapotranspiration and groundwater recharge processes.

Methods and disciplinary background: Observed time series of groundwater level and spring discharge will be used to analyze (e.g., as in Healy and Cook, 2002; Geyer et al., 2008) how groundwater recharge responded to hydro-meteorological extreme conditions and to identify potential changes in these responses over the last decades. A process-based soil hydrological model will be employed to improve the understanding of the mechanisms controlling evapotranspiration and seepage flow in the soil under the observed extreme conditions as well as under future changing environmental conditions.

References:

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Sustainable use of groundwater resources under changing climate conditions and the transition to a low-carbon society—hydrogeological constraints vs. societal demands

Main Supervisor: **Steffen Birk** [**showcase 2**]

Research field "Meteorology and hydrology: Groundwater resources in climate change"

Research question 2 | Cluster 2

Links to showcases Bednar-Friedl 1, Kirchengast 1, Kirchengast 2, Steiner 1, Maraun 2

Background: Groundwater resources (and more generally the subsurface) are subject to different methods of utilization, which include among others water abstraction for public, industrial, or agricultural purposes, extraction or storage of energy, and construction activities. Changing climate conditions as well as the transition to a low-carbon society may change the interrelation between the different types of usage and thus may create conflicts between them (different from those today). For instance, the transition to a low-carbon society potentially involves enhanced use of hydroelectric power and thus hydraulic structures affecting the stream-aquifer interaction; likewise geothermal energy use or storage depending on the type of technology potentially affects water quantity or quality; more frequent and/or more severe drought may increase the demand for both public water supply and irrigated agriculture. This leads to the following research questions: How will the demands on aquifers change in the transition to a low-carbon society and how can these demands be met using groundwater resources sustainably in a changing climate?

Goal: This thesis aims to assess how the demands on an aquifer system potentially change in the transition to a low-carbon future, and to identify criteria for the sustainable use of groundwater resources in a changing climate.

Methods and disciplinary background: For a selected aquifer system (e.g., in the region of Graz), a groundwater model is developed that accounts for the impacts of various human activities such as water abstraction and hydraulic engineering or other construction activities under current conditions. Different pathways of the future development in the transition to a low-carbon society are explored and implemented in model scenarios to assess how groundwater resources are potentially affected by changing demands (e.g., increased water abstraction for public water supply or irrigation) or related construction activities (e.g., hydraulic structures for hydroelectric power) as well as by changing climate conditions. The results will be used to examine the applicability of the concept of groundwater sustainability (e.g., Alley et al., 1999; Gleeson et al., 2012) under changing environmental conditions.

References:

Alley W. M.; Reilly T. E.; Franke O. L. (1999): Sustainability of ground-water resources, U.S. Geological Survey Circular 1186, 79 p.

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