Hydrological low-flow dynamics and damage risks due to extreme hot and dry spells in a warming climate

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Research field "Physical climate science: Uncertainties in atmospheric and hydrological changes in a warming climate"
Research question 2 | Cluster 1 (decision making) and Cluster 2 (adaptation)
Links to showcases Birk 1+2, Steiner 1+2, Bednar-Friedl 2, Schulev-Steindl 1+2, Meyer 1

Background: The expected intensification of extreme hot and dry spells under climate change in the warm season at middle latitudes, which likely leads to an increase of droughts in vulnerable catchments such as the Styrian Raab catchment in the south-eastern Alpine forelands of Austria, may have strongly adverse effects on different sectors such as agriculture, tourism, and energy production. As with the extreme rainfall events (showcase 1), the damages and costs caused by these extremes are a consequence of particular concern and also here further influences such as land use/land cover (LULC), soil property, and water management changes are important. In this showcase we focus on exploring low-flow impacts, again using the Styrian Raab catchment (987 km^2) as heavily observed and modeled "laboratory region".

Goal: Collaborating closely with showcase 1 and linking as well to showcases of the decision making and adaptation clusters, the thesis aims to answer these two complementary research questions: 1. How do runoff and soil moisture, and their local scale dynamics from small sub-catchments (~10 km^2) to full catchment area (~1000 km^2), respond to extreme hot and dry spells of different intensification characteristics and given different winter-spring initial hydrologic conditions, and how is this response enhanced or mitigated by LULC and soil property changes? 2. How do streamflow and soil moisture changes relate to agricultural and hydrological drought impacts and associated damage risks and costs and what is the fractional risk and cost attributable to human-made climate change? Here also we aim at robust process-based findings that are applicable to other comparable catchments.

Methods and disciplinary background: Building on DK phase 1 (e.g., Hohmann et al. 2017; Brunner et al. 2017; Haas and Birk 2017), we will use the hydrological model WaSiM, set up for the Styrian Raab catchment as described for showcase 1, though here at 3-hours or daily resolution for decadal simulation periods. We will drive WaSiM at the meteorological input side by high resolution synthetic and observational long term data (ZAMG & AHYD & WegenerNet station networks, 1982–2017; SPARTACUS & E-OBS gridded datasets, 1982–2017), optionally also embedded in future climate scenarios 2036–2065 and 2086–2115 (Postdoc work B. Lackner). Complementary agricultural and hydrological drought impact and associated damage and cost data are received from partner projects and the state of Styria. Modeling and analysis methods as noted for showcase 1 will be used to reach the aims.

References:

Hohmann, C., G. Kirchengast, and S. Birk (2017), Alpine foreland running drier? Sensitivity of a drought vulnerable catchment to changes in climate, land use, and water management, Clim. Change, in press/publ.online, DOI:10.1007/s10584-017-2121-y.

Brunner, L., G. C. Hegerl, and A. K. Steiner (2017), Connecting atmospheric blocking to European temperature extremes in spring, J. Climate, 30, 585-594, DOI:10.1175/JCLI-D-16-0518.1.

Haas, J. C., and S. Birk (2017), Characterizing the spatiotemporal variability of groundwater levels of alluvial aquifers in different settings using drought indices, Hydrol. Earth Syst. Sci., 21, 2421-2448, DOI:10.5194/hess-21-2421-2017.