Hydrological high-flow dynamics and damage risks due to extreme convective rainfall events 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 Maraun 1, Birk 1+2, Foelsche 1, Bednar-Friedl 2, Schulev-Steindl 1+2, Meyer 1, Sass 1+2

Background: The expected intensification of extreme convective rainfall events under climate change, which likely leads to an increase of flash floods and landslides 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 public infrastructure, households, and agriculture. The damages caused, and their related adaptation, mitigation or compensation costs, are a consequence of particular concern. Furthermore, and importantly, the climate change-induced hydrological changes, impacts, damages, and costs also co-depend on further influences such as land use/land cover (LULC), soil property, and water management changes. We focus in this context on exploring high-flow impacts, using the Styrian Raab catchment (987 km^2) as heavily observed and modeled "laboratory region".

Goal: Linking to other showcases of the decision making and adaptation clusters, the thesis aims to answer two research questions: 1. How do runoff and peak flow, and their local scale dynamics from small sub-catchments (~10 km^2) to full catchment area (~1000 km^2), respond to extreme convective rainfall events of different intensification characteristics and given different pre-event hydrologic conditions, and how is this response enhanced or mitigated by local LULC and soil property changes? 2. How do surface runoff, peak flow and soil moisture changes relate to flash flood and landslide occurrence and associated damage risks and costs, and what is the fractional risk and cost attributable to human-made climate change? We aim at robust process-based findings applicable also to other comparable catchments worldwide.

Methods and disciplinary background: Building on DK phase 1 (e.g., Hohmann et al. 2018; Schröer et al. 2018; Schröer and Kirchengast 2017) we will use the process-oriented hydrological model WaSiM, set up for the Styrian Raab catchment for investigating the hydrological response to extreme rainfall at 100 m / 30 min resolution, including newest high quality LULC and soil property data specifically prepared for this catchment. We will drive WaSiM at the extreme rainfall input side by high resolution synthetic, observational, and model-simulated event data (1-km scale ZAMG & AHYD station networks and WegenerNet, 2007–2017; 1-km scale convection-permitting COSMO-CLM extreme event simulations for 2009 and 2014, showcase Maraun 1), optionally also embedded in future climate scenarios near 2050 and 2100 (Postdoc work B. Lackner). Complementary flash-flood, land-slide and associated damage and cost data are received from partner projects and the state of Styria. Dynamical and statistical modeling, sensitivity analyses, and various data analysis methods will be used to reach the aims.

References:

Hohmann, C., S. O, G. Kirchengast, U. Foelsche, J. Fuchsberger, and W. Rieger (2018), Sensitivity of small-catchment runoff to spatial rainfall variability: a hydrological modeling study based on 1 km-scale sub-hourly heavy rainfall data, Hydrol. Earth Syst. Sci. manuscript in prep. [continued after return of C. Hohmann from 10-mon-leave by Feb.2018]

Schröer, K., G. Kirchengast, and S. O (2018), On the fundamental spatial resolution dependence of observed short-duration extreme convective rainfall intensity, Geophys. Res. Lett. manuscript in prep. [submission Mar.2018]

Schröer, K., and G. Kirchengast (2017), Sensitivity of extreme precipitation to temperature: the variability of scaling factors from a regional to local perspective, Clim. Dyn., in press/publ.online, DOI:10.1007/s00382-017-3857-9.