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A vulnerability analysis for a drought vulnerable catchment in South-Eastern Austria

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To detect uncertainties and thresholds in a drought vulnerable region we focus on a typical river catchment of the Austrian South-Eastern Alpine forelands with good data availability, the Raab valley. This mid-latitude region in the south-east of the Austrian state Styria (∼ 47° N, ∼ 16° E) exhibits a strong temperature increase over the last decades. Especially the mean summer temperatures (June to August) show a strong increase (∼ 0.7 °C per decade) over the last decades (1971 - 2015) (Kabas et al., Meteorol. Z. 20, 277-289, 2011; pers. comm., 2015). The Styrian Raab valley, with a catchment size of 986 km^2, has already struggled with drought periods (e.g., summers of 1992, 2001 and 2003). Thus, it is important to know what happens if warm and dry periods occur more frequently. Therefore we analyze which sensitivities and related uncertainties exist, which thresholds might be crossed, and what the effects on the different components of the water balance equation are, in particular on runoff, soil moisture, groundwater recharge, and evapotranspiration.

We use the mainly physics-based hydrological Water Flow and Balance Simulation Model (WaSiM), developed at ETH Zurich (Schulla, Diss., ETH Zurich, CH, 1997). The model is well established and widely used for hydrological modeling at a diversity of spatial and temporal resolutions. We choose a model set up which is as simple as possible but as complex as necessary to perform sensitivity studies on uncertainties and thresholds in the context of climate change. In order to assess the model performance under a wide range of conditions, the calibration and validation is performed with a split sample for dry and wet periods.

With the calibrated and validated model we perform a low-flow vulnerability analysis (“stress test”), with focus on drought-related conditions. Therefore we simulate changes in weather and climate (e.g., 20% and 50% less precipitation, 2 °C and 5 °C higher temperature), changes in land use and land cover (e.g., less forest/grassland, more agriculture/sealed land), and changes in water use and water management (e.g., more irrigation/groundwater use). By analyzing the effects of such changes on the water balance parameters runoff, soil moisture, groundwater recharge and evapotranspiration, we gain insight into the vulnerabilities of the catchment. We also characterize the general behavior of the hydrological system, in particular the low-flow processes, and identify the most critical parameter combinations under changing environmental conditions. As a result we are able to assess if thresholds may be crossed and what conditions pose climate change risks, in particular towards the increase of droughts.