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How catchment characteristics determine hydrological sensitivity to climate change in a mountainous environment

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The anticipated climate change in Switzerland will result in changing precipitation patterns and increasing temperatures during the first half of the 21^{st} century (OcCC 2007). These changes will have an impact on the hydrological systems, too, in particular in mountainous regions. The objective of our study is to determine those catchments that exhibit sensitivity towards a change in climate, and to identify specific catchment characteristics causing this sensitivity. Both issues will be addressed in the framework of the joint research project "Climate Change in Switzerland – Hydrology" (CCHydro) which was initiated by the Federal Office for the Environment (FOEN).

In the present study, the hydrological modelling system PREVAH (Precipitation-Runoff-EVAporation-HRU related model, Viviroli et al. 2009a) is used to examine mesoscale catchments in Switzerland. It is a semi-distributed and conceptual yet process-oriented model run on the basis of hourly meteorological input, and at a spatial resolution of 500 x 500 m^2. This spatial and temporal resolution is a necessary prerequisite to meet the high degree of heterogeneity of mountainous environments. Where measured discharge is available, catchments were successfully calibrated both for standard and flood conditions using an iterative search algorithm designed to maximize objectivity of the calibration procedure (Viviroli et al. 2009b). The parameter values thus obtained were transferred to ungauged catchments subsequently. For this, a regionalisation scheme was used (Viviroli et al. 2009c) to arrive at a comprehensive set of model parameters for the entire area of Switzerland.

A total of 17 Regional Climate Models (RCMs) from the ENSEMBLES-project (Hewitt & Griggs 2004) were interpolated to meteorological station locations at the Institute for Atmospheric and Climate Science (IAC) at ETH Zurich (Bosshard et al. 2009) using the Delta Approach (Prudhomme et al. 2002). The Delta Change Signal was calculated for the period 2021 to 2050 relative to the reference period 1976 to 2005. The annual cycle of the Delta Change is added to the observed time series to generate a set of climate scenarios with which the regionalised catchment models are forced.

To check the climate scenarios for hydrologic plausibility, they are applied to six test regions first, each of them representing a natural landscape unit of the Northern Alps. The results of this plausibility tests are evaluated, and the climate scenarios will be applied to approximately 200 mesoscale catchments with an average area of 150 km^2 and a range of 30 to 2000 km^2 to be able to specify causal (i.e. process-based) relationships between climate sensitivity and specific catchment characteristics.

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