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Climate-ensemble projections for the investigation of possible changes in runoff in an Alpine watershed

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The Alps are particularly sensitive to climate change. In this region the global warming since the mid 1980s has been roughly three times higher than the global average. The projected increase in temperature and the changes in precipitation regime may lead to considerable shifts in runoff. The aim of the present investigation was to assess how climate change may impact the runoff regime of an Alpine catchment. The Lech Valley ($\sim$1,000 km^2), situated in the Northern Alps, was selected as study area.

A one-way model chain from GCM to RCM and finally to the hydrological model was applied to investigate possible changes in runoff. An ensemble of nine climate projections provided by the EU-funded project ENSEMBLES was used to simulate the climate of the 2050s (2040-2069) and the 2080s (2070-2099). The delta change approach overcame the gap between RCMs and the hydrological model. An observed 30-year time series (1971–2000) of precipitation and temperature was perturbed according to mean monthly changes between the RCM runs. The main advantage of this technique is that the deviations between observation and the RCM output are negligible as the relative changes between the control run of the RCM and the future scenario are assumed to eliminate possible errors involved in the simulations. Thus, a broad range of available RCM outputs can be taken into consideration.

The hydrological simulations were applied with the semi-distributed model HQsim in an off-line mode. Both the calibration and validation of HQsim indicate that the model simulates runoff well in a complex topography like the Lech Valley. The Nash-Sutcliffe Coefficient for calibration (1981-2000) constitutes 0,87 and for validation 0,84 (1971-1980) and 0,89 (2001-2005). When driving HQsim with future climate data it is assumed that the calibrated parameters of the model will also be valid in changed environmental conditions.

The climate scenarios show an increase in monthly temperatures between 1.8°C and 2.4°C in the 2050s and between 2.7°C and 3.8°C in the 2080s. Accompanying significant changes in the seasonal precipitation patterns were obtained, including an increase in the precipitation from November to May and a decrease in the precipitation from June to August. The resulting effects of the runoff indicate large seasonally varying changes. Both a decrease in monthly runoff during summer and an increase in winter minimize the inter-annual disparities between low runoff in winter and high runoff in spring and summer. Due to these changes water management will face new challenges in future.

In contrast to existing investigations the use of an ensemble of different GCM-RCM combinations in this study allows to assess uncertainties in the climate projections.