IMPACTS OF CLIMATE CHANGE ON WATER RESOURCES IN SWITZERLAND AND ITS IMPLICATION FOR THE RHINE RIVER

Finger, D. [1], Glaus, N. [1], Hüsler[1], F., Köplin, N. [1] and Weingartner, R. [1]
[1] Institute of geography – University of Berne, Hallerstr. 12, CH-3013 Bern, Switzerland

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1 Abstract

Several interdisciplinary research projects (e.g. ACQWA, CCHydro, MontanAqua) have been investigating the impacts of climate change on water resources in the Swiss alps and its implication for hydropower and downstream water availability. The approaches to project water resources based on downscaled, error corrected climate scenarios ranged from modeling with physically based, fully distributed hydrological models applied to medium size catchments (Vispa valley, 778 km^2) to regionalized conceptual models for the entire alpine region of Switzerland. The results of these studies reveal drastic changes in runoff generation, as most of the alpine glaciers will drastically shrink throughout the 21st century. Ongoing research is investigating the contribution of snow melt, glacier met and local precipitation in runoff from small scale alpine case studies. In this presentation we will give an overview of the results and propose an outlook for future investigations.

Effects of climate change on hydropower production in the Vispa valley (Finger et al., 2012)

In Switzerland hydropower accounts for 55% of the national electrical power production. In the Vispa valley two hydropower companies (Mattmark AG and Grande Dixence S.A) collect natural runoff from over half of the entire catchment in reservoirs. In order to assess climate change impacts all relevant hydropower operational rules (e.g water abstraction, deviation of mountain streams, storage in reservoirs and routing of pressurized water to the turbines) were implemented in a physically based hydrological model. Using a stochastic calibration technique modeled natural runoff was calibrated against observations from upstream mountain streams and snow cover extent from satellite images. Subsequently, the calibrated model was used to project future runoff and hydropower production by using the most recent RCM scenarios for Europe from the EU FP6 Integrated Project ENSEMBLES (http://ensembles-eu.metoffice.com/). The model results indicate that ice melt and rainfall runoff will increase during the first half of the 21st century but decline during the second half. While the annual runoff will decrease on a long term, melt water will become available earlier in the season. Finally, the study makes suggestions how infrastructure of power plants could be adapted to future runoff dynamics.

Regionalization of climate change impacts on runoff (Köplin, 2012)

The climate change impacts on runoff in Swiss mesoscale catchments were assessed using the conceptual hydrological model PREVAH. The model was calibrated automatically for gauged catchments and subsequently the model parameters were regionalized by transferring parameters to ungauged basins. Finally, ten climate model chains were applied to 189 catchments to assess future climate change impact on runoff. The results indicate that temperature and winter precipitation will increase while summer precipitation will decrease. Furthermore, as a consequence of changes in snow accumulation and snow- and ice-melt due to higher temperatures, catchments with average altitude between 1000 to 2500 m a.s.l. will be most affected by temperature changes. Below 1000 m a.s.l. changes in runoff are dominated by changes in precipitation patterns. In catchments that have currently a glaciation of more than 10 %, the projected summer runoff highly depends on projected glacier retreat. In snow-fed catchments the projections reveal an increase of flood events during the

winter season. Furthermore, the projections indicate an increase of the magnitudes of annual high flows, although changes in the frequency and intensity of precipitation are not significant.

Implications for the Rhine River (Bossard, 2012; Huss, 2012)

The impact of climate change on river stream has been investigated using the conceptual hydrological model PREVAH. The results indicate that at the Cologne gauge projected runoff at the end of the 21st century decreases in summer and increase in winter. While runoff in alpine regions is particularly influenced by temperature changes, downstream regions are primarily influenced by precipitation changes. The relative importance of glacier contribution to runoff does not scale linearly with the percentage of glacierization, as high glacier runoff in summer dominates low-land areas with little precipitation and high evapotranspiration (Huss, 2012). Thus, glacial melt waters are relevant to the hydrological regime of macroscale watersheds and do not only have regional impacts. Projections of glacier retreat until 2100 indicate a reduction of glacierized areas in the Alps to 12% of the current value. In consequence, summer runoff contribution from currently glacierized basins will be strongly reduced.

Potential of snow cover satellite images to estimate snowmelt contribution (Glaus, Hüsler and Finger, in preparation)

Daily satellite snow cover images provide valuable information about the percentage of snow cover in watersheds (Hüsler, 2012). Recent studies demonstrated that snow melt contribution to total runoff can be estimated with snow cover images and efficiency of hydrological models increases if snow cover images are used for calibration purposes (e.g. Finger et al., 2011). Hüsler et al. are currently investigating snow melt contribution to run off in a tributary of the Rhine in the Swiss headwaters using snow cover percentages retrieved from daily satellite images. The preliminary results indicate that snow melt is the dominant contribution in medium sized catchments during almost the entire first half of the hydrological year. These new investigations could provide helpful information to decrease uncertainty of runoff projection in the Rhine River.

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