Glacier compensation effect: Change of streamflow variability in Alpine catchments

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INTRODUCTION

Glaciers are not only important water resources, contributing to streamflow by glacier melt, but also crucial regulators of streamflow. The modulating role of glaciers is described in the glacier compensation effect. This effect is caused by an opposite response to precipitation in the two parts of a glacialized catchment: the glacierized part and the non-glacierized part. The main controlling factor of melt is the surface energy balance, where precipitation is the main driver of runoff in the non-glacierized area. During precipitation events, solar radiation is reduced, which has a negative effect on the runoff from the glacierized part of the catchment. Opposite, during warm and dry conditions, runoff from the glacierized part is favored. Thus, in cooler and wetter years (periods), rainfall is arising from precipitation over the non-free part of the catchment, offsetting the reduced glacier melt in warm and dry summers (periods), enhanced glacier melt compensating for the reduced precipitation, resulting in lower inter annual streamflows dominating for moderately glaciated catchments.

THEORY

LITERATURE REVIEW

The streamflow modulating role of glaciers has been analyzed in a few studies (e.g. Fountoulakis & Tafuro, 1985; Chen & Ohrnner, 1990). They found that the streamflow response to precipitation is on average 2-3% for annual and 4-5% for inter-annual variability and plotted against average temperature and glacier cover.

DATA

- Streamflow data of glacierized catchments in Switzerland and Austria
  - Glacier cover range: 5% - 65% (2010)
  - Catchment size: 10 - 1000 km²
  - Annual precipitation range: 1000 - 3000 mm
- High resolution analysis: 1995 - 2014 (15 sub-catchments in both Switzerland and Austria)
- Grid-based precipitation (P) and temperature (T) data (1 km)

HYPOTHESES

- Spatial differences in variability and glacier cover are proxy for changes in variability over time (space for time substitution)
- Variability will increase/decrease depending on optimum glacier cover
- Optimum glacier cover depends on climate and catchment characteristics
- The compensation effect is more pronounced at larger time scales (days to year & daily in annual streamflows)

RESULTS & DISCUSSION

RESULTS CATCHMENTS

In these catchments, only glacier % differs. Variability is, for both annual and monthly streamflow, higher for the higher relative glacier cover. We would suspect that the optimum glacier cover is smaller than 28%, which is not expected from the optimum curve presented in the literature.

OUTLOOK

- Time scales of variability: intra-annual variability on higher temporal resolution – within-year variability
- Include elevation, snow cover and more detailed climatology data
- Measurement of change in CV (virtual time series) – is CV good measure?
- Modelling experiment with changing glacier cover + Calibration

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Data NDF P (insular), Meteorology, ZWR