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Quantifying the influence of various climate components and their uncertainties on the hydrological cycle in Alpine headwaters

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To simulate the effects of climate change on glaciation and runoff, hydrometeorological models are needed. Due to the fact that measurement data with high temporal and spatial resolution over several decades is sparse in high mountain regions, models which require little input data have to be applied. Simple semi-empirical approaches often fulfill this requirement and are able to reproduce runoff and glaciation quite well, but sometimes do not resolve physical processes adequately. As a result, different models can reproduce glacier mass balance and total runoff quite well but differ in the response to climate change scenarios at the same time. Questions such as (1) what are the requirements for an accurate determination of individual components, (2) what are the possibilities to reduce uncertainties of discrete components and (3) what can be done for assessing the propagation of input uncertainties on model output uncertainties of a hydrometeorological model have to be answered.

In order to examine these issues in Alpine headwaters the present study uses both, in situ data as well as gridded data. The hydrometeorological model OEZ, which has been developed at the Institute of Meteorology and Geophysics (University of Innsbruck) and which has been tested repeatedly, is applied. It is revealed that the use of multidisciplinary synergies leads to a reduction of uncertainties of discrete components. While precipitation amounts in the lowest altitudinal range of a catchment can be recorded by valley stations, inverting the hydrological cycle enables to simulate precipitation on the catchment scale. Beside precipitation also temperature is a highly sensitive input parameter. But very often only monthly values are available over several decades. This temporal resolution is too low to resolve important melting and freezing cycles and to determine the solid fraction of precipitation within a month. Based on such mean monthly temperatures, representative probability density functions for temperature distributions enable to assess the probabilities for freezing temperatures within a time step.

In order to capture the propagation of input uncertainties on total model output uncertainty, a Monte Carlo simulation framework is used. This approach shows that uncertainties are high, especially during late spring and summer.