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Model based historical runoff contribution from an Alpine glacier

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The aim of this work is to analyze how climatic variability and glacier retreat impact the water balance of a small (8.5 km2) glaciarised catchment in the Eastern Italia Alps over a 30 year (1983-2013) period. The analysis is carried out by coupling local high quality data and a glacio-hydrological model able to simulate both the glacier and hydrology dynamics. Runoff contribution from glacier ice is related with trends in climatic variables and with glacier retreat.
The area analyzed is the headwater of Noce Bianco river basin, lying in the Ortles-Cevedale group and including the La Mare glacier. During the study period the glacier area decreased from 4.7 km2 (50% basin area) to 3.47 km2 (40% basin area). In this area the following observations are available: 30 years of daily meteorological data at high elevation close to the catchment; three DTMs of the glacier, covering the entire period, which enable the calculation of the volume change and geodetic mass balance; direct glaciological mass balance observations over the period 2003-2013; discharge measurement at the catchment outlet over the period 2007-2013. The data availability and the significant shrinking of the glacier during the analyzed period make this catchment ideal for studying the hydrological impacts of glacier retreat. The semi-distributed conceptual model includes a snow and glacier accumulation and ablation module, based on temperature-radiation index and a glacier retreat model. The glacier retreat model allows to use the annual simulated glacier mass balance to update the glacier area (Huss et al., 2010). The model simulations are carried out from 1983 to 2013.
We show that the model is able to capture adequately the measured daily discharge, the observed changes in glacier area and their spatial distribution. The contribution of glacier ice meltwater to annual runoff is below 10% in the first decade of simulation. This variable however showed a clear increasing trend, with peaks for single years above 50% and an average above 25% in the last 10 years of simulation. The contribution of water from glacier melt have peaked around 2003, and the glacier volume in the simulation has been more than halved during the 30 years. Beside the reduction of runoff from glacier ice after 2003, the modelling approach allowed to highlight also an increase of the inter-annual variability in meltwater runoff in the last ten years.