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Present and future contribution of glaciers to runoff from macroscale drainage basins in Europe

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Glaciers are important storage components in the hydrological cycle. Their runoff yield is often anticorrelated to water stress in the low-lands. With the strong recession of Alpine glaciers expected for the 21st century, the question of water supply security in the summer months both for small mountainous catchments and for macroscale transboundary watersheds arises.

The contribution of glaciers to stream-flow runoff from large-scale drainage basins in Europe is analyzed for the major streams originating in the Alps – Rhine, Rhone, Po and Danube. Detailed information on glacier storage change is available from monthly mass balance data for 50 Swiss glaciers for the period 1908-2008. Storage changes are extrapolated to all glaciers in the European Alps. By comparison of monthly runoff yields from glacierized surfaces in the summer months and measured runoff at gauges along the entire length of the streams, the relative portion of glacier melt water for each month is calculated.

The drainage basin of the Rhone with a size of 100'000 km^2 (1% ice-covered) shows a 26% contribution of glacier storage change to August runoff over the last century. In the lower Danube (0.06% glacierization) glacier melt water accounted for 8.5% of observed runoff in September of the extreme year 2003. 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. Thus, glacial melt waters are relevant to the hydrological regime of macroscale watersheds and do not only have a regional impacts. By transiently modelling future glacier retreat until 2100 using climate scenarios, a reduction of glacierized area in the Alps to 12% of the current value is found. In consequence, summer runoff contribution from currently glacierized basins will decrease, intensifying issues with water shortage in summer also in poorly glacierized catchments.