

Extreme heat and runoff extremes in the Swiss Alps.

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To date the 2003 summer has been the hottest for central Europe since instrumented observations exist (Schär et al., 2004). The effects of the 2003 heat wave in central Europe have been definitely also amplified by the concurrent low precipitation amounts. Many authors believe and prophecy that such an event is only a forerunner of similar events in the years to come as a follow of global climate warming and increased temperature and precipitation variability over central Europe.

The coincidence of unusual hot and dry weathering caused by such particular atmospheric circulation is rather interesting from the hydrometeorological point of view, since such conditions are the most frequently declared projections of changing climate in Central Europe for summers in the second half of the 21st century. In contrast the high uncertainty of the climate projections, the 2003 summer event can rely on observed time series of the meteorological boundary conditions and especially of the actual reaction of the hydrological system in terms of water fluxes.

Thus, this unexpected “2003 scenario” is a very valuable test bed in order to evaluate if currently adopted hydrological models, which have been developed and designed in order to provide reliable estimates on the spatial and temporal distribution of water resources under current climate conditions are actually able to provide reliable projections on hydrological impacts of climate change when forced by time series modified by predicted climate scenarios.

Other questions arise about differential hydrological impacts of summer heat waves, especially in very sensitive environments like mountainous regions in central Europe. The Swiss Federal Office for Environment FOEN recorded runoff extremes at several stream flow gauges of its network during 2003. Two antithetic behaviours have been identified: a) extreme low flows in mesoscale rivers of the Swiss Plateau; b) extreme high runoff in highly glacierized headwater basins.

This study will put a focus on the response of Swiss Alps rivers to the extreme meteorological conditions occurred in 2003. Following main topics are discussed: a) Local and regional characterization of the 2003 summer flow rates in Switzerland with respect to the long term averages. b) Analysis of the differential impacts of the 2003 summer heat wave by mean of distributed hydrological modelling with the PREVAH model (Gurtz et al. 2003). c) Identify reasons for such differentiated response of the Swiss rivers and to quantify the particular contribution of icemelt to the discharge. d) demonstrate whether hydrological models are able to estimate heatwave triggered lows flows events, which are expected to increase in the coming decades.

The left side of Figure 1 shows the evolution of the observed anomalies in 2003 from small glaciated headwater basins to the main gauges of three large river systems within Switzerland (Aare, Rhône and Rhine). The effects of the 2003 heatwave are

less pronounced in the Rhône basin. The portion of glaciated areas is clearly above 10% up to the Porte Du Scex gauge. A strong compensation to the generally reduced runoff generation by enhanced melting of ice occurred during summer 2003 up to Porte Du Scex.

The two other large rivers are less glacerized and therefore more affected by the drought. If we consider the response of basins with area between 1000 and 10000 km², then the anomalies in the Rhine are 20% to 30% apart from the values of the Rhône. The evolution of the anomalies for the Aare River system is somewhat in between of the other two rivers.

Distributed hydrological simulations (right side of Figure 1) clearly indicate that the adopted model is able to capture the differential impact of the 2003 events in the Swiss Alps. Both the simulation of the long term average and the simulation of hydrological response during the 2003 heatwave are of good quality.

The study shows the importance of long-term monitoring of discharge rates in order to understand and quantify impacts of extreme low flow events on water resources. The application of hydrological models allows the realization of reliable spatially distributed analysis and impact studies for such extreme situations, without further adaptation of their structure.

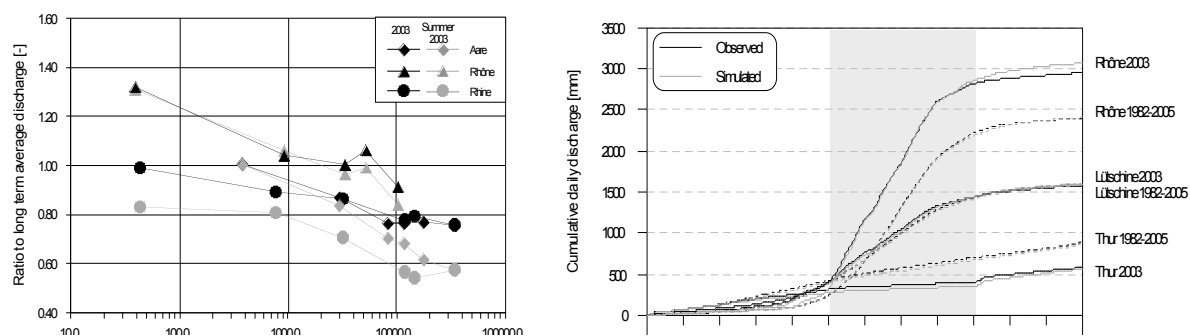


Figure 1. *Left side*: Deviation of the 2003 discharge from the long term average (full year and only summer) for the three main river systems in Switzerland and selected upstream gauges. *Right side*: Cumulative observed and simulated discharge for three basins showing different response to the 2003 heatwave. Observed and simulated cumulative averages for the period 1982-2005 are also plotted.

REFERENCES

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