

## Streamflow trends in Switzerland

Marius-Victor Birsan, Peter Molnar, Paolo Burlando & Martin Pfandner\*

Institute of Hydromechanics and Water Resources Management, ETH Zurich, Switzerland

\*Federal Office for Water and Geology, Bern-Ittigen, Switzerland

Mean daily streamflow records from 48 watersheds in Switzerland with an undisturbed runoff regime are analysed for trends with the Mann–Kendall nonparametric test in three study periods (1931–2000, 1961–2000, 1971–2000). The statistical significance of trends is tested for each station on an annual and seasonal basis and for different streamflow quantiles. The field significance of trends is tested by a bootstrap procedure. Identified trends in streamflow are examined together with changes in precipitation and air temperature, and correlated with watershed attributes. Complex changes in the streamflow regime in Switzerland especially in the more recent periods are demonstrated. The main identified trends are an increase in annual runoff due to increases in the winter, spring and autumn season runoff, an increase in winter maximum streamflow (at more than 60% of the stations) and an increase in spring and autumn moderate and low flows. The behaviour in the summer period is different, with both upward and downward trends present in moderate and low flow quantiles. Many of the trends are field significant. Changes in precipitation are not sufficient to explain the observed trends in streamflow. Air temperature, most notably a substantial increase in the number of days with minimum daily temperature above 0 °C, may explain some of the observed increases in winter and spring season runoff. Correlation analyses reveal a strong relationship between streamflow trends and mean basin elevation, glacier and rock coverage (positive), and basin mean soil depth (negative). These relationships suggest that the most vulnerable environments from the point of view of streamflow change are mountain basins.