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A three-pillar approach to assess climate impacts on low flows and droughts in Austria

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Current climate change scenarios suggest an increasing risk of droughts and associated low streamflows for European water bodies. The possible impacts have been assessed in a number of studies which are either based on a mechanistic or upward approach (model chain experiments of climate scenarios) or a downward approach (trend analysis of streamflow observations). The projections from these studies, however, are still highly uncertain, due to either the uncertainty of climate change scenarios, or the limited record length of streamflow observation.
In this paper we present the results of the Austrian project Climate Impact of Low Flows and Droughts (CILFAD) which was designed to overcome the limitations of upward and downward studies using a three-pillar approach. The first pillar is the assessment of observed streamflow trends. We compare an innovative regional trend analysis using functional clustering with classical local trend analysis using the robust Sen-slope estimator. The second pillar is the assessment of changes in the climate signal. The analysis employs various meteorological drought indices calculated from log-term regional data (HISTALP data set) and assesses their link to the low flow signal. The third pillar consists of climate projections using a mechanistic model. The innovative idea combines rainfall-runoff projections of low flows with stochastic projections of low flows and droughts. While rainfall-runoff projections are based on climatic time series on low flows, the statistical characteristics of these time series, such as time series characteristics (estimated parameters and uncertainty) of precipitation and temperature, are used for the stochastic projections. By combining both innovative ideas we believe to assess climate change impacts more reliable than it is possible with applying the usual scenario technique alone.
From the results negative trends (more severe droughts) are predicted for SE-Austria and, with lesser significance, for the very North of Austria. They relate to decreasing flows in summer, and are possibly related to increasing evapotranspiration. However, positive trends are predicted in the Central Alps. They occur mainly in winter, and are obviously related to a reduction of snow storage due to temperature increase. From a combined assessment of the three different approaches, we derive estimates of expected change and discuss their uncertainty. We claim that the combination of upward and downward approaches provides a wealth of information particular useful to derive more reliable estimates than each of the approaches separately.