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Quantifying the present-day human influence on temperature, precipitation, and runoff in an pre-Alpine Swiss catchment

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Understanding the influence of anthropogenic greenhouse gas (GHG) emissions on climate and environmental variables is still a challenge in science. Many detection and attribution studies have been carried out focusing on global and regional scales or on single events. However, the influence of anthropogenic greenhouse gas emission on both, runoff regime and driving meteorological characteristics is still an open question.
This study assesses the influence of anthropogenic GHG emissions on temperature, precipitation, and river runoff in a pre-Alpine catchment in Switzerland. For this purpose, thousands of one-year (April 2000-March 2001) simulations representing both, a present-day climate with actual anthropogenic GHG concentrations (A2000), and a climate with pre-industrial GHG concentrations (A2000N) were bias-corrected and used to analyze changes in temperature and precipitation. The two variables were then used to drive the hydrological model GR4J including the snow module Cemaneige for the river Thur (1700 km2). Comparing the runoff of the two scenarios and calculating the fraction of attributable risk (FAR) as well as the change in probability of occurrence (PR) for specific runoff thresholds enabled the assessment of the influence of anthropogenic GHG emissions.
We found higher mean runoff in winter and spring in the A2000 scenario compared to the A2000N scenario. This is mainly caused by the combination of higher precipitation and higher temperatures in winter resulting in less snow accumulation in the A2000 scenario. Therefore, more liquid water is available in the hydrological model leading to enhanced runoff. In contrast, the A2000 simulations exhibit lower runoff in summer and autumn than the A2000N simulations. We relate this to higher temperatures in the A2000 scenario enhancing evapotranspiration and lower precipitation amounts. The calculation of FAR and PR for different runoff thresholds indicates that the FAR and PR increase with higher thresholds suggesting stronger influence of anthropogenic GHG emissions on the very high river flows. The bias-correction led to a reduction of FAR and PR and to an increase in the corresponding uncertainty ranges. This study demonstrates that temperature and precipitation in Switzerland as well as the runoff regime and runoff extremes have changed due to the emission of anthropogenic GHGs. It also highlights the influence of bias-correction on the estimation of FAR and PR.