



Climate Change Impacts on Alpine Springs: Shifts in Discharge Seasonality and Water Availability

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Spring water is a vital resource and a cornerstone of Austria's drinking water supply, providing roughly half of the national demand and serving as the sole source in some regions. Ongoing climate change is rapidly modifying hydrological conditions, particularly in the Alpine region. Understanding the future evolution of spring discharge dynamics is therefore essential for the sustainable management of Austria's water resources. This study investigates the impact of climate change on 76 alpine springs distributed across Austria. For each spring, several potential catchments are delineated and a rainfall-runoff model incorporating a snow module is used to determine the most plausible catchment. Subsequently, the model is driven by climate input data from three RCP scenarios (2.6, 4.5, and 8.5) to assess climate change impacts up until the year 2100. Comparing three model periods (historical reference, near future, and far future) enables a systematic assessment of temporal changes and climate change impacts. Analyses are carried out for individual springs and for hydrologically classified groups with specific discharge characteristics. The results reveal a pronounced shift in seasonal discharge especially for fast-responding and snow-dominated springs, characterized by a strong increase in discharge during spring months for snow-dominated springs and a marked decrease in summer discharge for both fast-responding and snow-dominated springs. Furthermore, the timing of the 7-day minimum flow shifts into the summer season for all spring groups. Examining the spatial patterns of individual springs across Austria reveals that, in the near future, a decrease in total discharge is projected in the southwest of Austria under all RCP scenarios. In contrast, the far future shows an improvement for alpine springs under RCP 2.6 and 4.5, whereas under RCP 8.5, decreases in total discharge are projected to become more widespread across Austria. These findings offer a meaningful reference for future water management planning in Austria, highlighting potential trends while acknowledging scenario-based uncertainties.