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Improving predictions of stream temperature changes under warming using flow regimes

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Changes to air temperature will influence the water temperature, habitat suitability, and biogeochemical processes, especially in cold and alpine regions. However, the timing and magnitude of these impacts depends on the full energy and water balance of the stream, which can be difficult to implement using standard monitoring data. Here, we demonstrate the use of a regime-based water temperature analysis framework to capture the important spatial and temporal contrasts in these energy and water balance dynamics. The underlying joint analysis of water temperature and discharge regimes shows that there is a hysteresis over the annual cycle between discharge and water temperature that shifts depending on the influence of snow and glacier melt vs rainfall on discharge. This hysteresis undermines the ability to use simple regression models to predict stream temperature changes, especially when discharge is expected to also change. Moreover, more complex statistical and numerical models of stream energy balances are not always able to capture this hysteresis. Our analysis of all unperturbed streams of Switzerland with long term monitoring suggests that a joint water temperature – discharge regime analysis has great potential to characterize the sensitivity of stream water temperature to ongoing climate warming, with relevant implications for ecology.