Projecting future Swiss river temperatures on a National scale while maintaining local features

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A key water quality indicator for both ecosystem and human water needs is river temperature, which is expected to change as climate warms. River temperatures are strongly controlled on regional to local scale by hydrological and atmospherical processes upstream. Therefore, when studying influencing factors on river temperatures it is desirable to use local-scale atmospheric data. Yet, climate change is a global phenomenon, usually studied with Global Circulation Models (GCMs), which sometimes are coupled to Regional Climate Models (RCMs), through the use of Representative Concentration Pathway (RCP) climate scenarios. This coupling produces climatic projections on a relatively coarse spatial scale. However, local biases are a huge problem for the use of thes projections in local-scale, especially in mountainous regions. For Switzerland, most biases have been removed by downscaling GCM-RCM coupled models to the local scale in the CH2018 project (2018). Switzerland's use and management of water resources is already impacted by a changing climate. As temperatures increase, glaciers recede and snow is present for fewer days each year, affecting both temperature and discharge of streams and rivers (FOEN (ed.), 2021). One important consideration for riverine temperature management is the tolerance threshold for aquatic life. The Swiss Water Protection Ordenance stipulates that river water may not be thermaly used once the temperature exceeds 25 ^{o}C, which is the critical temperature for the survival of the Brown Trout (FOEN (ed.), 2021).

To simulate river temperatures, one important process to include is river flow. Yet, the coupling of advanced discharge models with water temperature models and the consideration of a sufficient number of climate change projections is often unfeasible on the regional scale due to computational constraints. Here, we present a physically based, semi-empirical modelling approach with two surface water temperature models (air2stream and air2water) to provide regional projections of future river temperatures in Switzerland. Our method was first applied in Basel and has since been expanded to project future river temperature at all river stations where the Federal Office of the Environment monitores water temperature. Our approach simplifies the computation of river temperatures while maintaining local robustness by including the most important factors affecting river water temperature (i.e., air temperature, discharge variations, seasonality and river depth). We project river water temperatures based on locally downscaled climate forcings from 9 GCM, 8 RCM, 3 RCP scenarios and future river flows from 4 discharge models. Our results beeing presented spann a wide variety of river thermal types including alpine, regulated, groundwater springs, plateau, and downstream lake types.

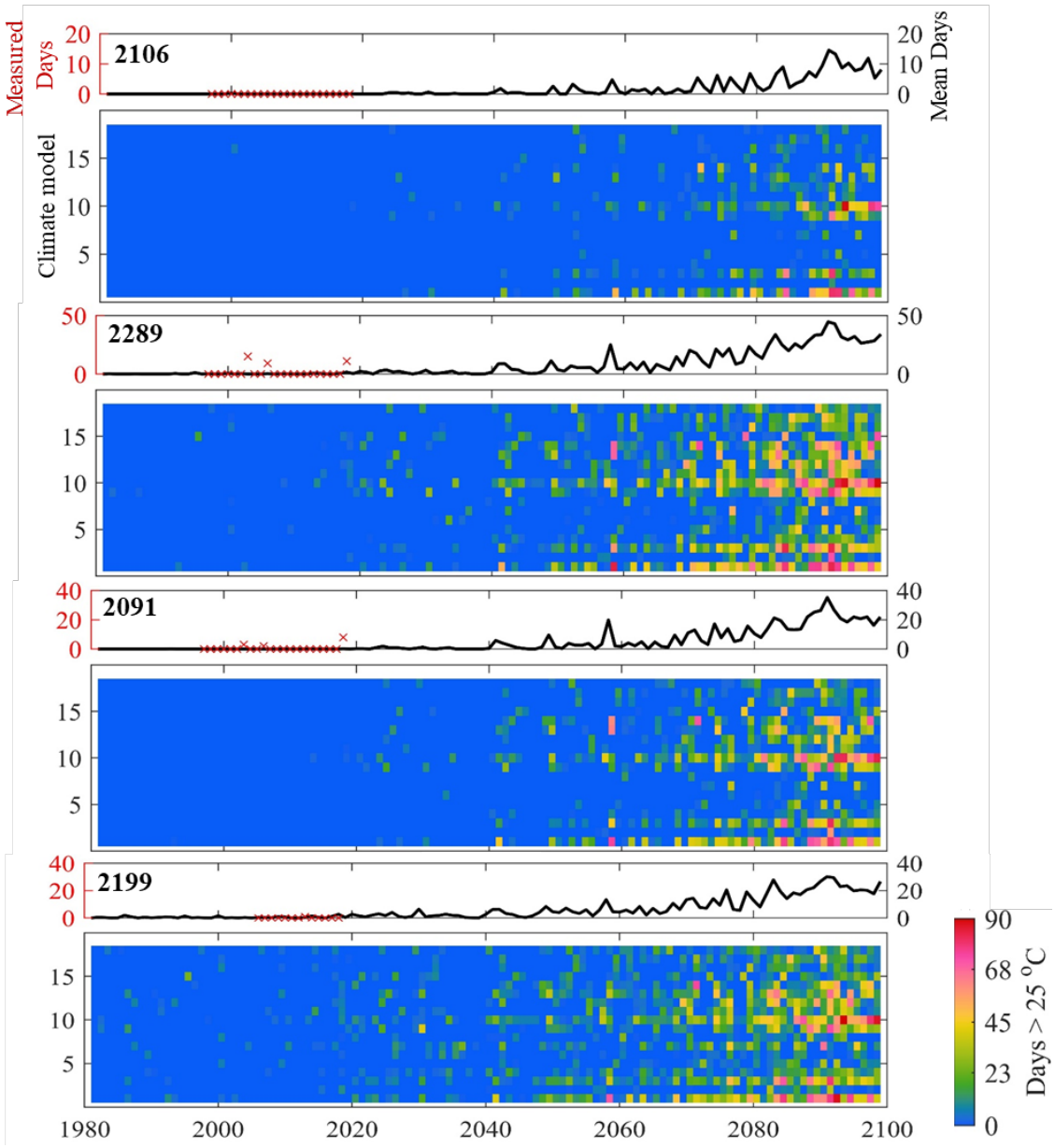

Figure 1. The total number of days per year during which river water temperatures exceed 25 °C at stations 2106 (Birs), 2289 (Rhein), 2091 (Rheinfelden) and 2199 (Wiese) for RCP8.5. Top figures: Mean threshold values from all climate models combined (black line) and from measurements (red crosses). Bottom figures: Simulation results from individual climate models (Epting et al., 2023).

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