CoolHydro – mitigating extreme temperature events in hydropower catchments

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ABSTRACT: Water temperature is a key factor influencing biological activity and habitat suitability in freshwater systems. Many Norwegian River systems are hydrologically altered by hydropower regulation. A common plant layout is comprised of a reservoir and an underground penstock leading to a downstream power plant, often fairly distant from the reservoir. Release flows from dams are in many cases constant for extended periods and a large share of the natural discharge in summer and fall is not available in bypass sections. The resulting flows in bypass reaches are characterized by reduced water quantity and flow dynamics. Additionally, cold releases from high-altitude reservoirs can significantly alter the downstream temperature regime (thermopeaking).

In Norway, climate change is projected with increased precipitation in form of rain during winter and earlier snowmelt in spring, leading to a reduction in winter ice habitats both spatially and temporally. Additionally, more dry and warm periods may lead to cause more frequent and longer dry spells with peak temperature events. Water temperature peaks can be exacerbated in the bypass reaches under hydrological climate change: Low discharge rates and larger surface areas in these areas can result in increased net heat transfer compared to the natural, historical state.

However, well-timed hypolimnetic cold water releases from high-altitude reservoirs can help mitigate downstream peak temperature events.

This study aims to I. demonstrate a modelling framework for water temperature in regulated freshwater systems, II. assess the impact of climate change and hydropower regulation on river temperature in Nordic catchments and III. evaluate the effectiveness of adaptive hydropower operation strategies in mitigating peak temperature events. The study employs a distributed hydrological model, HYPE, calibrated using regional calibration and Differential Evolution Markov-chain routines to simulate discharge and water temperature using historical data. This model is coupled with a 1D lake model, MyLake, to simulate depth-distributed water temperature and ice behavior in individual reservoirs.

We focus on selected regulated and unregulated test case catchments and evaluate different historical and future water temperature scenarios downstream of hydropower plants and in the bypass sections. Downscaled CMIP5 climate forcing data of is bias-corrected and various release strategies are tested.

Preliminary results demonstrate satisfactory performance of the hydrological model in simulating discharge and temperature, with a bias to early-freeze up and delayed snowmelt.