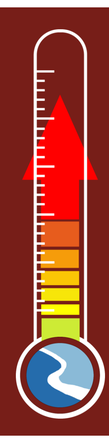
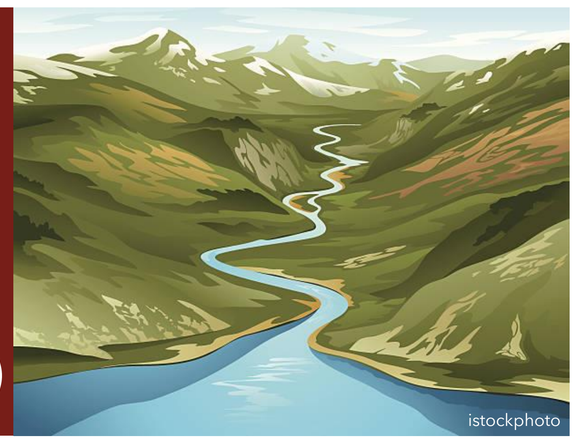
Trends and drivers of extreme water temperatures in mountain rivers

Amber van Hamel[1,2,3] & Manuela I. Brunner[1,2,3]

[1]Institute for Atmospheric and Climate Science, ETH Zurich; [2]WSL Institute for Snow and Avalanche Research SLF;
[3]Climate Change, Extremes and Natural Hazards in Alpine Regions Research Center CERC

Contact: amber.vanhamel@slf.ch





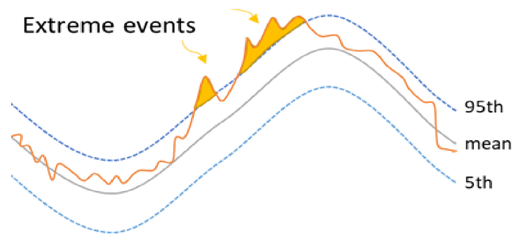
Introduction

Due to climate change and more frequent extreme weather phenomena, such as heat waves and drought, the risk of higher water temperatures increases. Since water temperature is one of the main variables regulating physical, chemical and biological processes in streams, extreme water temperatures potentially result in severe impacts on aquatic ecosystems. However, knowledge of water temperature extremes remains limited.

Aim: improve our understanding of the temporal changes and driving processes influencing the occurrence of water temperature extremes in Alpine rivers.

What are extremes?

- Water temperature extremes: water temperature values exceed a local varying 95th percentile threshold.
- Extreme events: a period of x-consecutive days for which the water temperature exceeds the 95th percentile threshold.



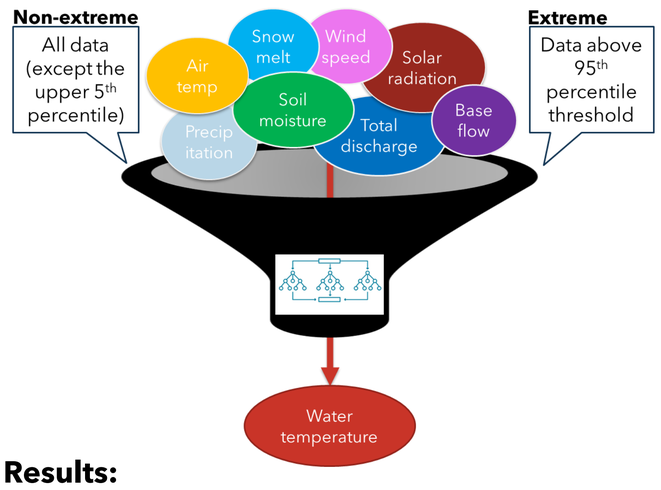
Conclusions

- Our observations of extreme water temperatures suggest that aquatic ecosystems in mountain rivers will likely be more affected by extreme water temperatures in the future.
- The driving processes of water temperature extremes are not the same as the processes of non-extreme water temperatures.
- Current models that only use air temperature and discharge might not be suitable for the prediction of water temperature extremes at high elevations.

Water temperature extremes are driven by other processes than non-extreme water temperatures

Methods:

- **Random Forest models**: Per catchment, we developed two Random Forest (non-parametric regression) models to obtain the variable importance for non-extreme and extreme water temperature.
- 139 catchments in the Alps and Scandinavia



Results:

- Driving processes for extreme water temperature are different than drivers for non-extreme water temperature: soil moisture is more important and air temperature is less important.
- At high elevations, baseflow is an important predictor for both non-extreme and extreme water temperature

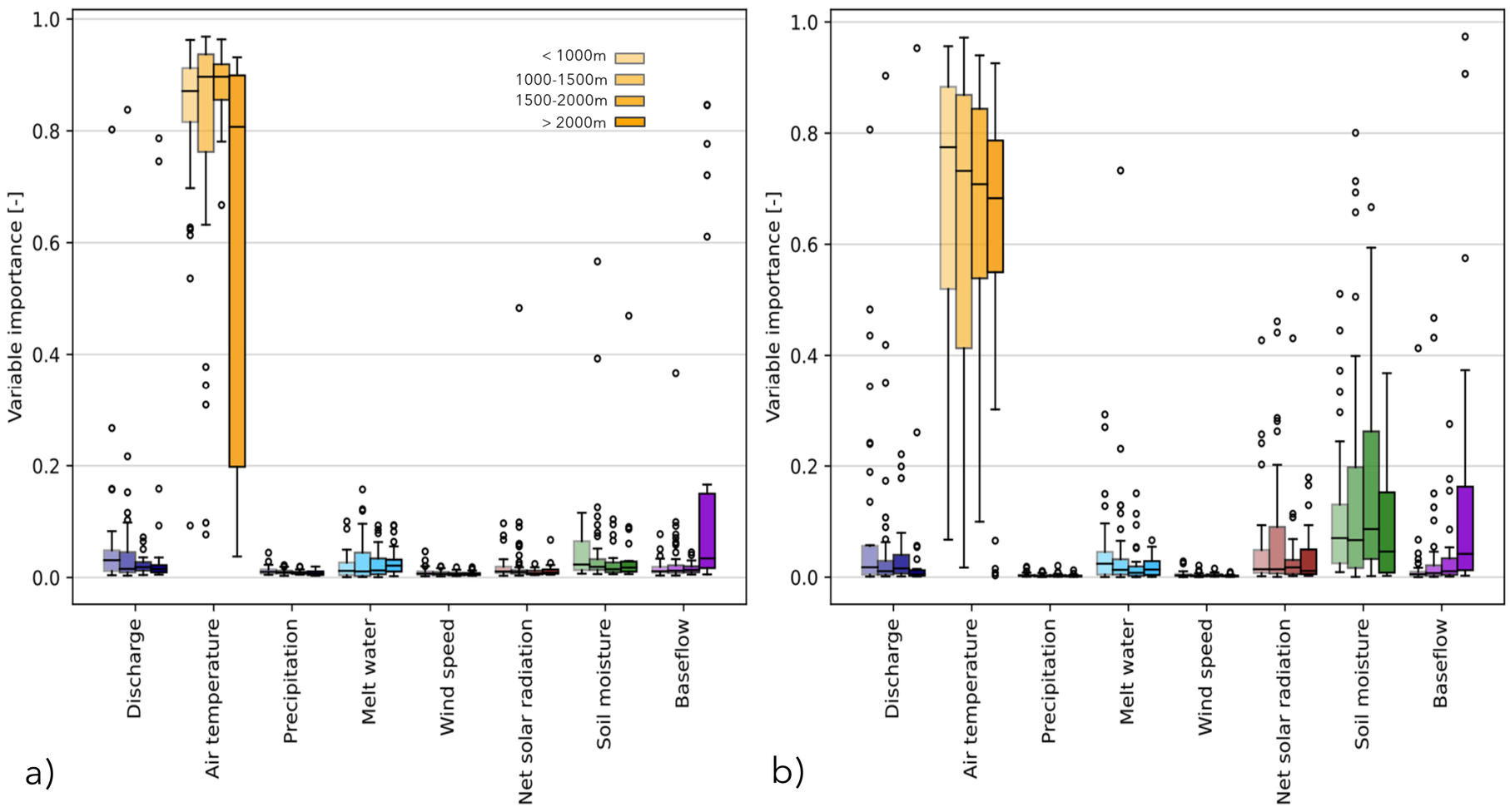


Figure 1. Variable importance of eight main predictors of water temperature for different elevation groups for (a) non-extreme water temperatures and (b) extreme water temperatures.

Stronger summer trends in extreme than in non-extreme water temperatures

Methods:

- We did a trend analysis on 30-year data series of water temperature in 18 Alpine catchments for the period 1991-2021, for water temperature extremes and extreme events.

Results:

- Water temperature shows an average long-term positive linear trend of +0.38 ± 0.14 ºC per decade, with the strongest trends in summer (+0.46 ± 0.15 ºC per decade) and the weakest in winter (+0.24 ± 0.09 ºC per decade).
- Trends in extreme water temperature in summer are stronger than the observed trends in non-extreme water temperature (see fig 2, yellow box).

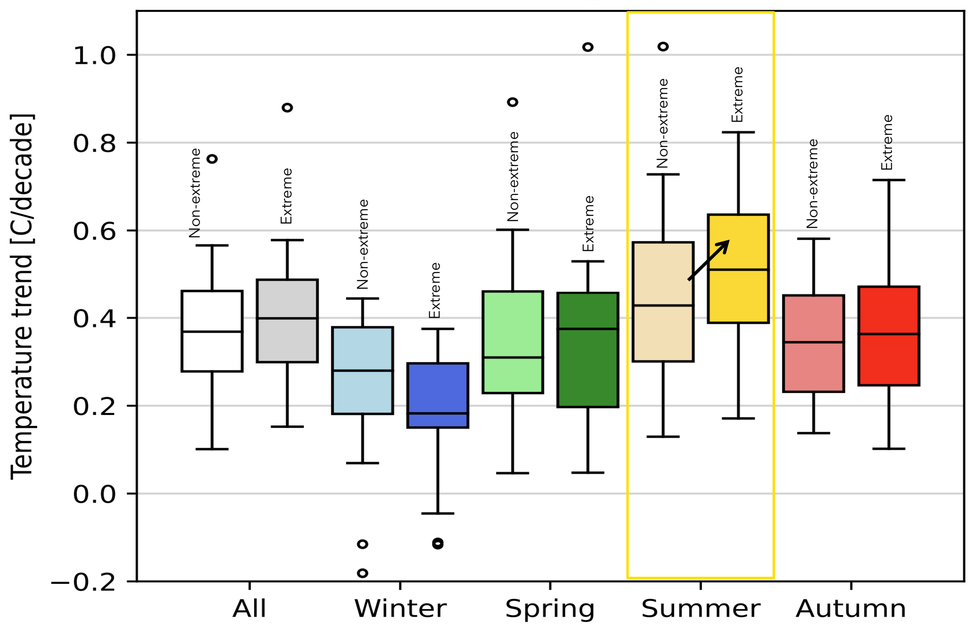


Figure 2. Boxplot with the seasonal water temperature trends of 18 Alpine catchments for the period 1991-2021 in average (non-extreme) and for the monthly maxima (extreme).

High elevations show the strongest increase in extreme events

Results:

- All catchments show an increase in the number of extreme events over time.
- The most severe extreme events are mainly found at low elevations. However, the strongest increase in the number of extreme events is found at high elevation.

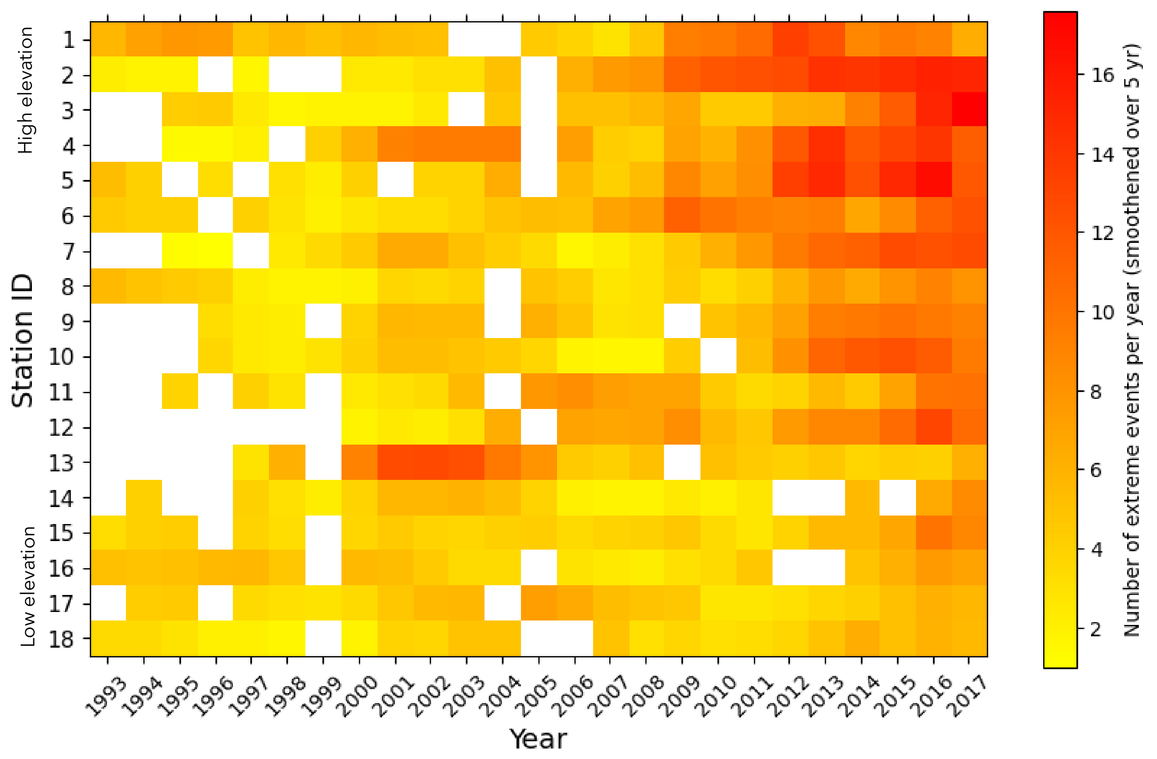


Figure 3. Number of extreme events per year per catchment (smoothened over 5 years) for the period 1993-2017.

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