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Trend of stream temperature and its drivers over the past 55 years in a large European River basin

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Air temperature has been increasing all around the world over the past decades. Owing to its sensitivity to air temperature, it is consequently expected that stream temperature experiences an increase as well. However, due to paucity of long-term stream temperature data, assessments of the magnitude of such trends in relation with landscape and hydrological changes have remained scarce.

The present study used a physically-based thermal model (T-NET: Temperature-NETwork), coupled with a semi-distributed hydrological model (EROS) to reconstruct past daily stream temperatures and discharges at the scale of the Loire River basin in France (10^5 km^2 with 52278 reaches). The ability of both models to reconstruct long-term trends was assessed at 44 gauging stations and 11 stream temperature stations.

T-NET simulations over the 1963-2017 period show that there has been a significant increasing trend in stream temperatures for at least 70% of reaches in all seasons (median=0.36 °C/decade). Significantly increasing trends are more prominent in spring (Mar-May) and summer (Jun-Aug) with a median increase of 0.37 °C (0.11 to 0.8°C) and 0.42°C (0.14 to 1 °C) per decade, respectively. For 81 % of reaches, annual stream temperature trends are greater than annual air temperature trends (median ratio=1.21; interquartile ranges: 1.06-1.44). Greater increases in stream temperature in spring and summer are found in the south of the basin, mostly in the Massif Central (up to 1°C/decade) where greater increase in air temperature (up to 0.67 °C/decade) and greater decrease in discharge (up to -16%/decade) occur jointly. The increase of stream temperature is also higher in large rivers compared to small rivers where riparian vegetation shading mitigate the increase in temperature. For the majority of reaches, changes in stream temperature, air temperature, and discharge significantly intensified in the late 1980s.

These climate-induced changes in the annual and seasonal stream temperature could help us to explain shifts in the phenology and geographical distribution of cold-water fish especially in the south of the basin where trends are more pronounced.