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Water temperature sensitivity under climatic change: comparison between mountain and lowland rivers in the Loire basin

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Abstract In a context of climate change, the capacity to forecast the thermal regime of rivers is a major challenge for water resource management and for aquatic ecosystem preservation. To address the geographic distribution of daily water temperature within the entire drainage network of the Loire basin (110 000 km^2), we based our work on the equilibrium temperature concept, as developed in the ICC-Hydroqual project. Sixty-eight sub-basins (300 to 3000 km^2) are delineated, in which Strahler orders are considered to behave similarly. The model uses a heat balance with five terms based on meteorological variables provided by Safran interpolation analysis (8 km × 8 km) of Météo-France. The simulation of the river discharge was performed by means of the semi-distributed hydrological model EROS. The performance of the model for simulating water temperature over the last 33 years (1974–2007) for 71 sampling stations led to median RMSE = 1.97°C. Thermal regime at the end of the 21st century (2080–2100) was simulated using 13 changing climate (A1B) and hydrological scenarios derived by the EROS model. The combination of these scenarios results in the same increase of the mean annual temperature by 2.2°C (±0.6°C). The increase of the mean monthly temperature is similar for mountain rivers (mean basin elevation 600 m) and for lowland rivers (mean basin elevation 130 m). The water temperature increases by 3.0°C (±0.9°C) in spring and autumn and by 2.6°C (±0.7°C) in summer. This limited increase in summer can be explained by the rise of the energy loss by the net long-wave radiation and by the evaporative heat flux, correlated with a reduction of the increase of the net short-wave radiation.

Key words thermal models; climate changes; equilibrium temperature; mountain and lowland rivers; Loire Basin; France