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A spatially-explicit stream temperature model for ecohydrological applications

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Stream temperature is a key variable controlling chemical, biological and ecological processes in freshwater environments. Stream temperature models have a long history; however, most of them only focus on given river's cross-sections, whereas temperature gradients along stretches and tributaries of a river network are crucial to assess ecohydrological features such as e.g. aquatic species suitability, grow and feeding rates, disease transmission. Here, we propose a deterministic, spatially-explicit stream temperature model for a whole river network, based on water and energy budgets at a reach scale and requiring only easily available spatially distributed datasets such as morphology and air temperature. Heat exchange processes at the air-water interface are modelled via the widely known equilibrium temperature concept, but new parametrizations for this variable are here proposed. A case study was conducted on the prealpine Wigger river (Switzerland), where water temperatures have been measured in the period 2014-2017 at eleven spatially distributed locations. Results show the advantages of accounting for water and energy budgets at the reach scale for the entire river network, compared to simpler, lumped formulations. The spatially-explicit model enables the derivation of reliable estimates of mean daily stream temperatures for the whole catchment based on a limited number of conveniently located (namely, spanning the largest possible elevation range) measuring stations. Moreover, the use of a sinusoidal proxy for absorbed solar radiation in the computation of equilibrium temperature resulted in enhanced model performances compared with more classical parametrizations.