Daily model of stream temperature for spatial and temporal predictions

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Abstract

Introduction

Temperature is a critical factor in regulating the chemical and biological properties of streams.

Physical

Dissolved oxygen

Water density

Circulation patterns

Stratification

Biogeochemical

Eutrophication

Nitrogen cycling

Biotic

Algae/eutrophication

Invertebrates

Amphibians

Fish

Can affect electricity, drinking water, and recreation (see van Vliet et al 2011)

Stream temperature models are generally divided into two categories: deterministic and statistical (ref: Benyahya et al 2007 review).

Stream temperature models can be used for explanatory purposes (understanding factors and mechanisms affecting temperature) and for prediction. Predictions can be spatial or temporal (forecasting and hindcasting). Forecasting can provide immediate information such as the expected temperature the next hour, day, or week as well as long-term information about expected temperatures months, years, and decades in the future.

Deterministic models are based on heat transfer and are often modeled using energy budgets (ref: Benyahya et al. 2007). The models require large amounts of detailed information on the physical properties of the stream and adjacent landscape as well as hydrology and meteorology. These models are useful for detailed site assessments and scenario testing. However, the data requirements prevent the models from being applied over large spatial extents.

Statistical models, in contrast, require less detailed site-level data and therefore can be applied over greater spatial extents than deterministic models.

Additionally, parametric, nonlinear regression models have been developed to provide more information on mechanisms than traditional statistical models (ref: Mohseni 1998).

Disagreement (conflicting evidence?) regarding the drivers of stream temperature

We describe a statistical model of daily stream temperature and apply it to a large geographical area. We use the model to predict daily stream temperature across the northeastern United States over a 30-year time record.

Methods

Statistical models of stream temperature often rely on the close relationship between air temperature and water temperature. However, this relationship breaks down during the winter in temperature zones, particularly as streams freeze, thereby changing their thermal and properties. Many researchers and managers are interested in the non-winter effects of temperature. The winter period when phase change and ice cover alter the air-water relationship differs in both time (annually) and space. We developed an index of air-water synchrony so we can model the portion of the year that it not affected by freezing properties.

We used a generalized linear mixed model to….

* correlation in space
* incorporate short time series as well as long time series from different sites
* incorporate disjunct time series from sites