Process learning of stream temperature modelling using deep learning and big data

Rahmani Farshid[1], Lawson Kathryn[1], Appling Alison[2], Oliver Samantha[3], and Shen Chaopeng[1]

[1]Pennsylvania State University Main Campus
[2]U.S. Geological Survey Center for Integrated Data Analytics
[3]USGS

November 16, 2022

Abstract

Stream water temperature is considered a "master variable" in environmental processes and human activities. Existing process-based models have difficulties with defining true equation parameters, and sometimes simplifications like assuming constant values influence the accuracy of results. Machine learning models are a highly successful tool for simulating stream temperature, but it is challenging to learn about processes and dynamics from their success. Here we integrate process-based modeling (SNTEMP model) and machine learning by building on a recently developed framework for parameter learning. With this framework, we used a deep neural network to map raw information (like catchment attributes and meteorological forcings) to parameters, and then inspected and fed the results into SNTEMP equations which we implemented in a deep learning platform. We trained the deep neural network across many basins in the conterminous United States in order to maximize the capturing of physical relationships and avoid overfitting. The presented framework has the ability of providing dynamic parameters based on the response of basins to meteorological conditions. The goal of this framework is to minimize the differences between stream temperature observations and SNTEMP outputs in the new platform. Parameter learning allows us to learn model parameters on large scales, providing benefits in efficiency, performance, and generalizability through applying global constraints. This method has also been shown to provide more physically-sensible parameters due to applying a global constraint. This model improves our understanding of how to parameterize the physical processes related to water temperature.

Hosted file

essoar.10509644.1.docx available at https://authorea.com/users/415409/articles/595203-process-learning-of-stream-temperature-modelling-using-deep-learning-and-big-data

Process learning of stream temperature modelling using deep learning and big data

Farshid Rahmani[1], Kathryn Lawson[1], Alison Appling[2], Samantha Oliver[3], Chaoeng Shen[1]

[1]Pennsylvania State University Main Campus

[2]U.S. Geological Survey Center for Integrated Data Analytics

[3]U.S. Geological Survey, Middleton, Wisconsin, USA

Stream water temperature is considered a "master variable" in environmental processes and human activities. Existing process-based models have difficulties with defining true equation parameters, and sometimes simplifications like assuming constant values influence the accuracy of results. Machine learning models are a highly successful tool for simulating stream temperature, but it is challenging to learn about processes and dynamics from their success. Here we integrate process-based modeling (SNTEMP model) and machine learning by building on a recently developed framework for parameter learning. With this framework, we used a deep neural network to map raw information (like catchment attributes and meteorological forcings) to parameters, and then inspected and fed the results into SNTEMP equations which we implemented in a deep learning platform. We trained the deep neural network across many basins in the conterminous United States in order to maximize the capturing of physical relationships and avoid overfitting. The presented framework has the ability of providing dynamic parameters based on the response of basins to meteorological conditions. The goal of this framework is to minimize the differences between stream temperature observations and SNTEMP outputs in the new platform. Parameter learning allows us to learn model parameters on large scales, providing benefits in efficiency, performance, and generalizability through applying global constraints. This method has also been shown to provide more physically-sensible parameters due to applying a global constraint. This model improves our understanding of how to parameterize the physical processes related to water temperature.