EPA Fact Sheet: River Basin Model-10

Introduction

The River Basin Model-10 (RBM10) is a one-dimensional mathematical model of the thermal energy budget of the mainstem Columbia and Snake Rivers. It simulates daily average water temperature under conditions of gradually varied flow. Similar models of this type have been used since the 1960s to assess temperature conditions in the Columbia and Snake Rivers.

The technical underpinning of RBM10 has been peer-reviewed, documented, and applied in a number of settings. Scientists have successfully applied versions of this model framework to rivers in the United States and abroad, including published studies by researchers at the University of Washington, U.S. Geological Survey, University of California at Los Angeles, and Wageningen University in the Netherlands.

Model Scope

The RBM10 model of the Columbia and Snake River mainstems was initially developed and peer-reviewed by the U.S. EPA in 2001. It has been updated to include more recent data. The geographic area of the model (see Figure 1) is the Columbia River from the international boundary with Canada (River Mile 745.0) to the mouth at Astoria, Oregon; the Snake River from Anatone, Washington (Snake River Mile 168) to its confluence with the Columbia River near Pasco, Washington; and the Clearwater River from Orofino, Idaho (Clearwater River Mile 44.6) to its confluence with the Snake River near Lewiston, Idaho (Snake River Mile 139.3). The Clearwater is included in the model domain to account for substantial cold water releases from Dworshak Dam that strongly influence lower Snake River temperatures.

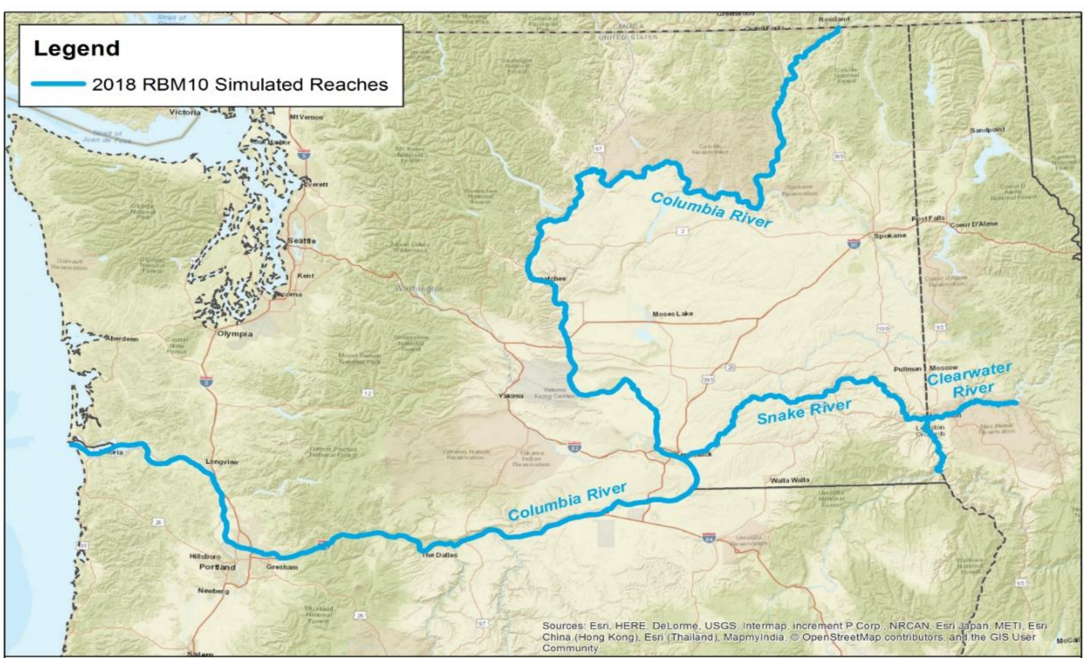

Figure 1

The model incorporates the following physical and thermal processes: hydrodynamics within each model segment (flow, velocity, channel geometry upstream boundary inputs), upstream boundary inputs (flow, temperature), heat inputs from tributaries, and surface heat exchange within each model segment.

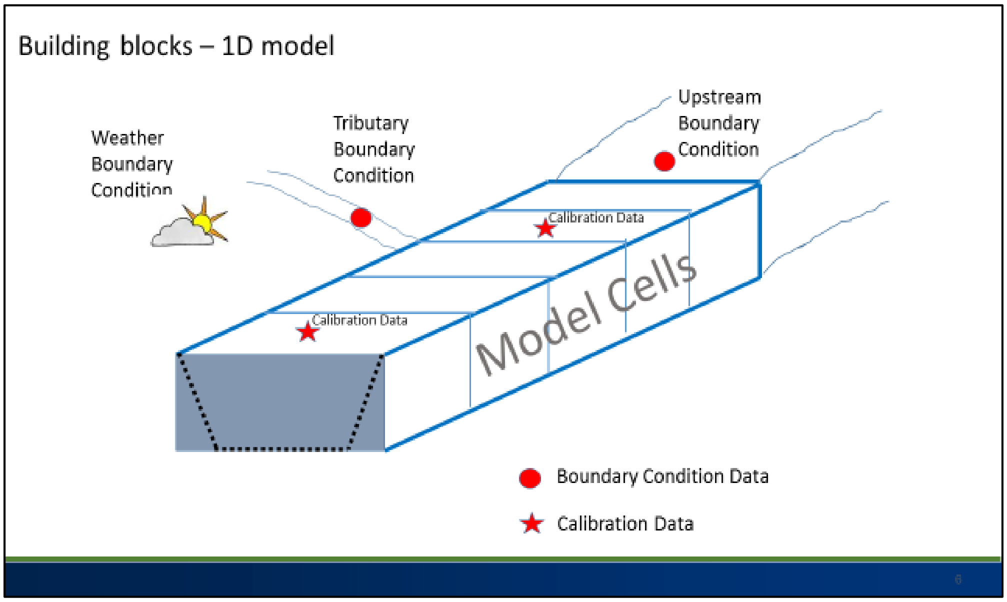

Figure 2

The tributaries included as flow and heat inputs to the model are shown in red in Figure 3 below. The model also includes water withdrawal at Grand Coulee dam.

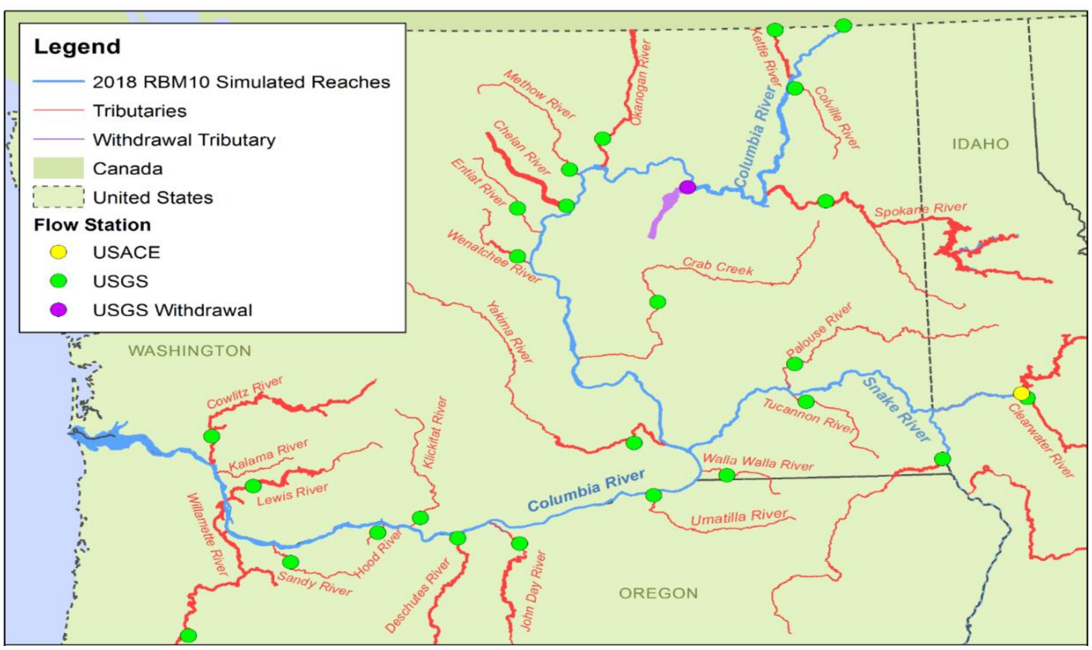

Figure 3

Using regional weather data, the model simulates the heat exchange processes that occur at the surface of the rivers and strongly influence water temperature (see Figure 4 below).

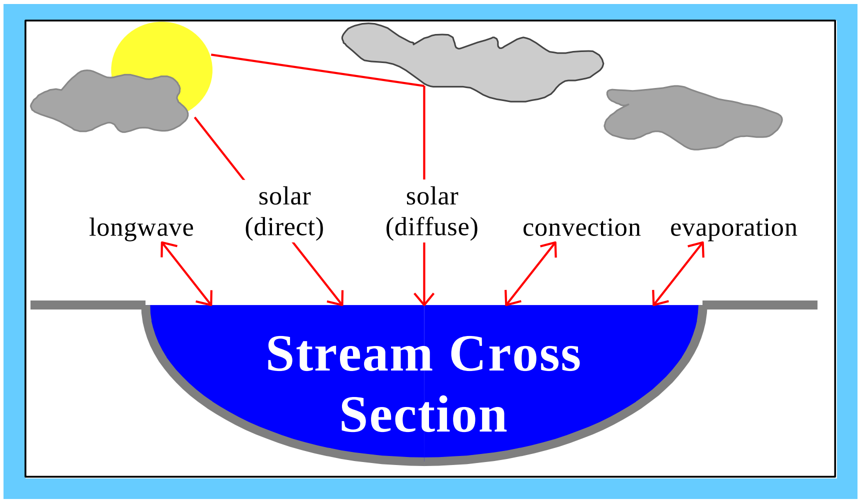

Figure 4

The updated RBM10 model simulates temperatures from 1970 through 2016, an unusually long simulation period for models of this kind. The simplicity of the model, combined with a novel methodology to solve the mathematical equations, allows for very fast simulation times compared to most other river temperature models. The RBM10 model can run the full forty-seven year simulation of daily temperatures in less than a minute on a standard laptop.

How Good are the Predictions?

We can check the model simulated temperatures against measured temperatures from the U.S. Army Corps of Engineers monitoring network (see Figure 5).

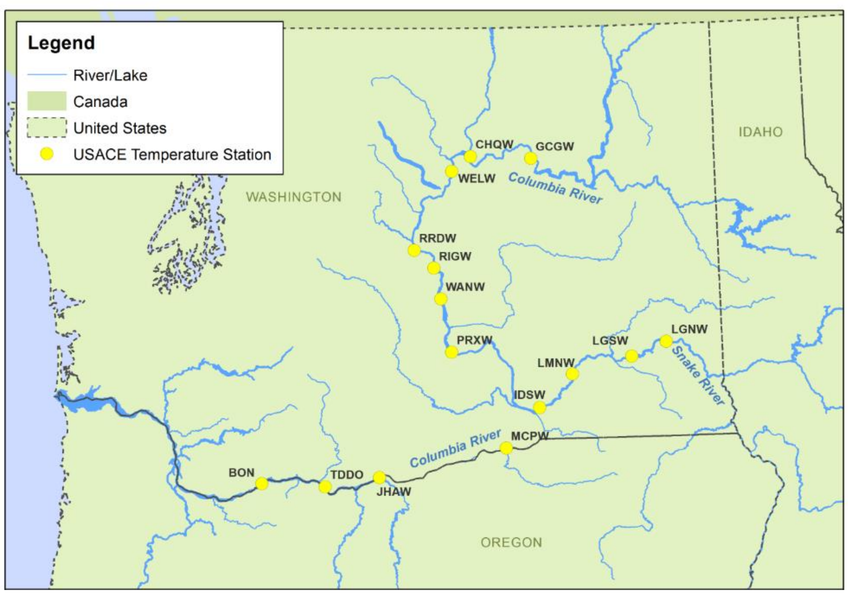

Figure 5

Comparing Simulated and Measured River Temperatures

Below are example plots at two locations: Bonneville Dam on the Columbia and Ice Harbor Dam on the Snake River for the most recent six years (2011-2016).

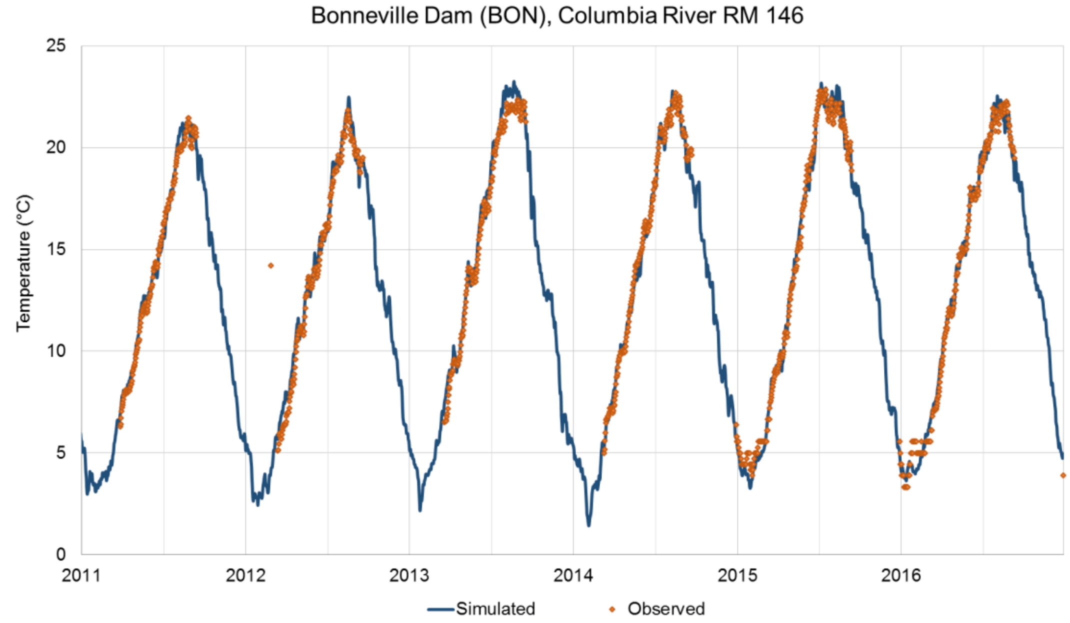

Figure 6

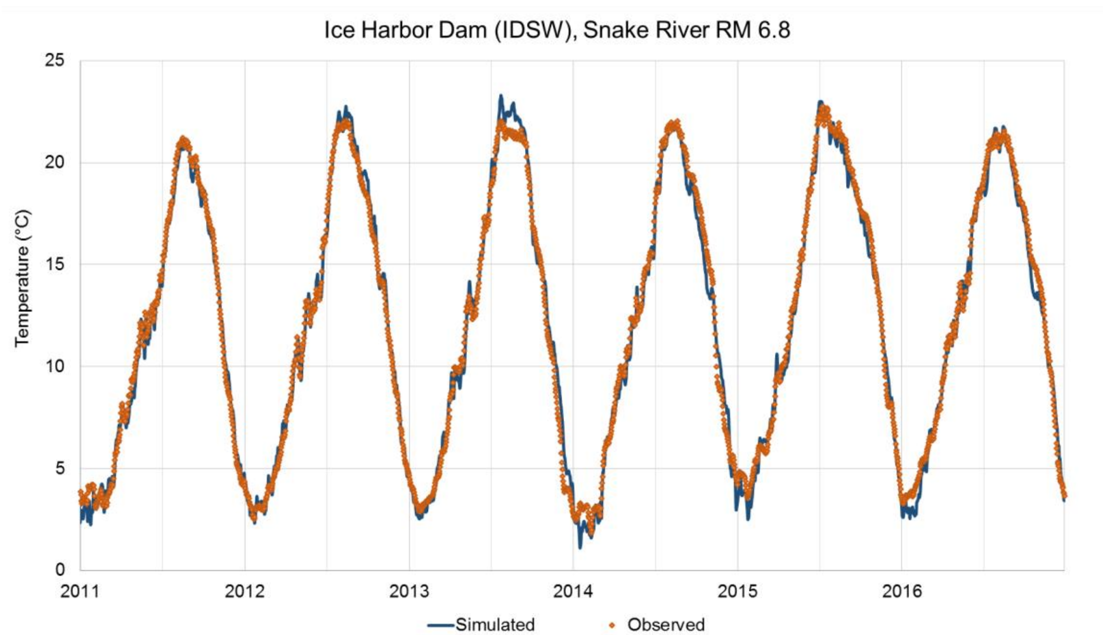

Figure 7

Long Term Average Conditions

It is difficult to show forty-seven years of results on a single sequential plot like the ones above, but we can plot the years on top of each other (shown below) and evaluate long term average conditions (yellow line) and the range of variation (thickness of the band of temperatures). The plot below shows the thirty-five years from 1970-2004. One can also see specific years where temperatures were substantially hotter and colder than the norm, such as September 1998 (hot) and August 1985 (cold).

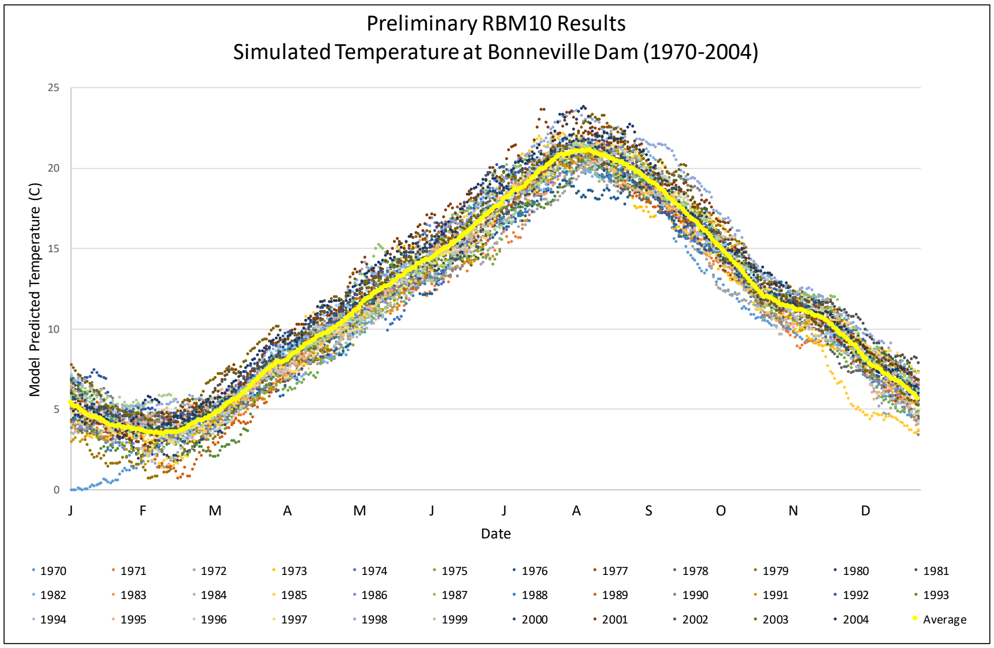

Figure 8

Impact Assessment

Once we have completed a review of the latest update of the model, we plan to use RBM10 to estimate changes on river temperatures caused by human activities while accounting for natural variability. For example, we can change the river channel to represent a free flowing river in the model. We can then compare "with dams" and "without dams" results to estimate the effect of the dams on river temperature. We can also use long-term model simulations to estimate the long-term rate of warming in river temperatures due to climate change. Other impacts include point source inputs and changes to tributary inflows.

Further Information

The full package of computer programs, supporting data files, and a report on how the model was developed can be obtained from:

Ben Cope
U.S. EPA Region 10
Modeling Lead
cope.ben@epa.gov
(206) 553-1442