The Hyporheic Transient Storage Model Component

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This document describes the Hyporheic Transient Storage model component (HTSComponent) that simulates heat and solute flux exchanges between hyporheic transient storage areas and the channel of rivers and streams. The HTSComponent was developed to be primarily used within the HydroCouple component-based modeling framework (Buahin and Horsburgh, 2016). However, it can be compiled and executed as a standalone executable.

# Formulations

Like the STSComponent, the HTSComponent was developed based on the formulations used by Bencala and Walters (1983), Kazezyılmaz-Alhan and Medina (2006), Neilson *et al.* (2010), and others, which simulates exchanges with other zones using a first-order heat/solute transfer relation as shown in Equation 1 for a control volume:

(1)

where is the density of the sediment in the hyporheic transient storage (HTS) zone , is the specific heat capacity of sediment in the HTS zone , is the temperature of the HTS zone , is the volume of the HTS zone , is the coefficient of thermal diffusivity for the sediment in the HTS CV, is the width of the HTS zone , is the length of the HTS CV , is the temperature of water in the main channel overlying the HTS zone , and represent the depths of the of the HTS and ground conducting zones respectively , is the ground temperature, and is coefficient of advective transport , represents solar radiation heat flux , is the light extinction coefficient , is the depth of water in the main channel overlying the HTS zone , and are heat fluxes supplied by other external sources . The time step for this model is limited by the following expression for stability:

(2)

## Solvers

The HTSComponent solves Equation 1 using several ordinary differential equation (ODE) solvers including the classical fourth order Runge-Kutta method (i.e., RK4) or the adaptive step size controlled fifth order Runge-Kutta-Cash-Carp (Cash and Karp, 1990) method. Alternatively, users can select variable multistep methods including the Adams-Moulton (i.e., ADAMS) formulas or the Backward Differentiation Formulas (i.e., BDF) that are provided through the CVODE (Hindmarsh *et al.*, 2017) external ODE solver library.

# Input File Format

The STS Component input file format is illustrated below. Values can be separated by space, tab, or comma delimiters. Delimiters can be any length.

# References

Bencala, K.E. and R.A. Walters, 1983. Simulation of Solute Transport in a Mountain Pool-and-Riffle Stream: A Transient Storage Model. Water Resources Research 19:718–724.

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Cash, J.R. and A.H. Karp, 1990. A Variable Order Runge-Kutta Method for Initial Value Problems with Rapidly Varying Right-Hand Sides. ACM Transactions on Mathematical Software (TOMS) 16:201–222.

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Neilson, B.T., S.C. Chapra, D.K. Stevens, and C. Bandaragoda, 2010. Two-Zone Transient Storage Modeling Using Temperature and Solute Data with Multiobjective Calibration: 1. Temperature. Water Resources Research 46:W12520.