Hydrol. Earth Syst. Sci. Discuss., 8, C1506–C1509, 2011
www.hydrol-earth-syst-sci-discuss.net/8/C1506/2011/

Hydrology and Earth System Sciences Discussions

Interactive comment on "Quantifying spatial and temporal discharge dynamics of an event in a first order stream, using Distributed Temperature Sensing" *by* M. C. Westhoff et al.

A. Wörman (Referee)

worman@kth.se

Received and published: 17 May 2011

General Comment

The objective of this paper is to provide insight into the spatial and temporal dynamics of stream water flow during a rainstorm event. In doing so the authors measure in-stream temperature continuously along the stream and discharge in several stations along the stream Maisbich in Luxemburg. The data time series are evaluated using one-dimensional models for hydraulic routing and heat transport. Exchange processes with the surrounding aquifer are considered in terms of groundwater inflow, hyporheic exchange and conductive heat transport with rock clasts. By evaluating different model configurations based on their statistical performance the authors conclude that the during rainstorm "gains of water remained constant for the whole simulation period, while losses of stream water increase with increasing discharge". Generally the model performs better during the first discharge peak of the event caused by direct precipitation, whereas the model fit is not as good for the second peak caused by subsurface storm flow and "bypasses" that successively become active during the event.

Overall the paper addresses an interesting and basic problem in runoff hydrology and stream flow generation. However, improvements can be made regarding a) the description of the model statements and b) the discussion of relevance of the optimization technique for identifying runoff processes. Further, the generality of the conclusions can be described clearer.

Mathematical formulation of the problem

The authors explain that they use the following models

1. A hydraulic routing model

2. A transport model for temperature

3. An energy balance model

The energy balance model "is a sink/source term in the transport model" that is given in terms of the Equations (1) – (3). Thus, it seems like there is actually only two models, one for water flow (representing conservation of momentum and continuity) and one for heat transport given by Equations (2) – (3). Eqn. (1) is part of the hydraulic model (i.e. the Saint Venants equations) and the two equation systems are solved uncoupled. Therefore, it is somewhat confusing that the authors discuss three models and include the continuity equation for water (Eqn. (1)) in the model for heat transport. The entire model description could be made clearer with regard to the water flow and heat transport models.

HESSD

8, C1506–C1509, 2011

A specific comment regards the formulation of heat exchange with the subsurface. In Eqn. (3) there are two terms on the right-hand side of the equation that describes the time rate of change of heat in the subsurface, a diffusive term and a first-order exchange term. What is the relationship between the temperatures Ts and Thz? My interpretation is that Thz is a constant temperature of the hyporheic zone and Ts is a time-variable temperature controlling heat conduction in the rock clasts.

In a comment on p. 2181, the authors claim that the exchange with the rock clasts (represented by the second term on the right-hand side of Equation (3)) is instantaneous. This is not correct. As formulated in Equation (3) the exchange rate due to the second term on the right-hand side is constant over time, but rate limited.

Further, this reviewer doesn't understand how the exchange between the stream water and hyporheic zone can affect the temperature of the rock clasts without a reverse effect on the hyporheic zone temperature from either/or both of the heat of the in-stream water or rock clasts.

Model optimization using multi-objective function

The authors introduce an innovative model optimization technique that includes a multi-objective criterion for both heat and discharge. However, it is not clear to this reviewer why some elements of the suggested method is superior to alternative statistical techniques, since no comparisons are made. The authors compare the model performance versus data with different model complexity, but alternative methods are missing.

A more thorough motivation would be needed regarding the splitting of the time series (first and second discharge peak) to determine different model parameters as well as the range of model uncertainties. For instance, why is the splitting of the time series needed if different model parameters are (really) reflected in distinctly different parts of the data? Wouldn't optimization using the entire time series reflect this automatically?

It is difficult to get the overview of the impact on model complexity on model errors.

Clearly the model formulation can be discussed in several aspects, such as exact formulation of exchange relationships as well as parameter variability in time and space. Some of these model parameters like flow velocity or cross-sectional width generally vary significantly and can be measured independently (from the applied techniques). Numerous investigations suggest that the hyporheic exchange varies with stream discharge (Wörman and Wachniew, 2007; Schmid et al., 2010). However, the authors acknowledge only a few model scenarios where Qhyp and Pb are spatially variable. Can the authors present specific observations or other findings not included in the current version of the paper that support this limited approach to spatial and temporal dynamics in stream flow generation?

Generality of conclusions

A main conclusion is that groundwater discharge to the stream is constant during the rainstorm event, whereas losses to bypass channels increase with discharge. There is a common understanding that stream flow generation is caused by the increasing groundwater discharge and not the ground surface runoff or precipitation falling directly on the water surface. The authors should develop this conclusion in comparison to previous understanding and/or rephrase it can be misunderstood.

References

Schmid, B.H., Innocenti, I., Sanfilippo, U., 2010. “Characterizing solute transport with transient storage across a range of flow rates: The evidence of repeated tracer experiments in Austrian and Italian streams”, Advances in Water Resources 33 (2010) 1340–1346

Wörman, A., Wachniew, P., 2007. “Reach scale and evaluation methods as limitations for transient storage properties in streams and rivers”, WATER RESOURCES RESEARCH, VOL. 43, W10405, doi:10.1029/2006WR005808

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 8, 2175, 2011.