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Discussions

Interactive comment on "Picturing and modelling catchments by representative hillslopes" *by* Ralf Loritz et al.

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Subject: A picture–perfect hillslope model?

The Discussion Paper: Highlight

I've enjoyed reading the authors' metaphysical discourse on, and in–depth analysis of, a high–resolution physics–based simulation of the headwater Colpach catchment in Luxembourg. What piqued my curiosity is their interesting but, to them, surprising finding on the utility of a conceptualized depression or storage in a hillslope.

The virtual storage is located on the foot and riparian zone of a representative hillslope, measuring 350 m in length, 54 m in height, and 42,600 m^2 in area. Equivalent in volume to all the depression storages in their reference model, it is created by an artificial *vertical*–barrier on the "left" boundary (not the "right" as in Line 555). The barrier is located in the lower 70% of a 1 m–deep soil profile above the weathered Schist bedrock. This is in addition to the no–flow boundary condition on the right–side margin.

The real hillslope is one of the 241 hillslopes comprising the 19.4–km^2 catchment, and representative in terms of their average length and height. The catchment, in terms of the area, almost doubles the sum of its representative hillslopes, i.e., 241 times 4.26 ha.

(See, among others, Subsection 4.4, Virtual experiments to search for first–order controls, Lines 708–717; Subsection 5.3.2, Is bedrock topography a first–order control at the Colpach? Lines 884–889; Table 2, VE2.3; and Figure 11(D).)

Balancing Nature's energy: Picturing a Muskingum River reach

From a parametric hydrology perspective on flood simulation, I imagine a catchment's storage *an invisible hand* in its response to rainfall–excess forcing (Ding, 2011, Section 7.5).

To keep track of filling and spilling of the lumped storage space, the authors may wish to consider an additional energy–balance equation. This is expressed in the form of a nonlinear Muskingum routing model (Ding, 2011, Equations 4 and 5):

$$Q = c^N S^N - c_1 \frac{dS}{dt}, \;\; N > 0, \; c > 0, \; c_1 \geq 0, \tag{1}$$

$$S = (1/c)[c_1 I + (1 - c_1)Q]^{1/N}. \tag{2}$$

Note in Equation (1), the discharge Q is a function of the storage S, and, more importantly, its time–derivative dS/dt. The latter term simulates the often observed $S - Q$ loop, a manifestation of the system hysteresis.

For a hillslope *recession* hydrograph, the degree of nonlinearity N is 2, meaning a quadratic storage (Ding, 2013, Equation 4; 2015). What remains are a scale parameter c and a weight factor c_1. (The weight c_1 varies between zero and one, likely having a mean value of 1/2 .) Having thus a maximum of two parameters, and a minimum of one, this storage (component) model is as concise as a kernel of truths should be.

A newly emerging picture of the catchment

The authors' finding on the utility of a conceptualized storage in a representative Colpach hillslope opens up a new vista of the headwater landscape. The expansive painting will be dotted by Muskingum–type objects in the river network itself as well as the hillslopes upstream.

An enhanceable lumped–storage element modelled after the Muskingum could be added, in parallel to or in series of, a CATFLOW–type distributed hillslope model. This will expand a lone hillslope model to truly a catchment one.

The authors, in their concluding paragraph, quote approvingly a maxim, attributed to Antoine de Saint–Exup$\acute{e}$ry, of drawing *a perfect picture* of the world. I characterize as *hysteresistical* his drawing manner of adding and subtracting things in a proverbial endless circle.

In his eye and his only, will *adding* a number of *lumped–storage* objects to a *distributed* hillslope model make it, the hillslope and catchment model, not picture–perfect? I hope not.

Afterword

This Short Comment is a latest of many sketches of many a catchment landscape.

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