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Hydrology and Earth System Sciences Discussions

Interactive comment on "Threshold behavior in hydrological systems and geo-ecosystems: manifestations, controls and implications for predictability" *by* E. Zehe and M. Sivapalan

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HESS Review paper by Zehe and Sivapalan on threshold processes

This is a long review paper on threshold behavior in hydrological systems, i.e. concerning processes occurring at the plot/hillslope and small catchment scale. The topic is very interesting and the authors introduced ideas on classifying threshold processes at different levels. However, before acceptance of the paper I suggest that this review paper should be somewhat more complete (see below) and a couple of points need to be clarified.

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Discussion Paper

General remarks:

The research objectives (P3252) are excellent, but I suggest modifying them such that the focus on small scales gets clearer from the beginning, and moving the second part of objective 4 to the front. I think the paper does not answer question 2 (‘.... conceptualize different forms of threshold behavior ....’) as much as the others. I stress the clarification of the focus of this paper on the small scales, as new processes and controls are coming in at larger scales that are not discussed in this paper. All examples are from the hillslope and headwater catchment scale (<5 km2; incl. 2.4.2 which examples could almost all fit to 2.1 Process-level). Processes like the space-time variability of hydro-climatological variables or stream flow routing processes play a much larger role at larger scale, but are not really discussed in this review paper. The text at 3264 top is also not clear on this and needs clarification. The functional scale discussion should be illustrated with better examples of catchment scale phenomena (not the macropore discussion again).

I found the discussions about the function level (e.g. 2.4) generally not so good. Beside the dominant focus on small scales, I missed the importance of the human impacts at this scale. Most of the catchments around the world are not pristine but heavily influenced in their dynamic behavior through man. The authors mention land use impacts, but there are also many others like reservoirs, abstractions (i.e. irrigation in semi-arid environments!), channel works, other water uses etc., which are not discussed in this paper.

The repeated tea-pot analogy is generally good and helpful for the reader, but it should be clarified that in the pot only the external force (heating energy) is changed and this triggers a switch of processes. However, the boundary conditions remain the same at the tea pot, but usually change completely for threshold processes in real-world hydrological systems.

Specific remarks:

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1) Too much of the paper is focused on reviewing own recently published studies. Other literature is referenced to some extent, but almost exclusively all examples refer to own work of the authors. I think a review paper should be somewhat wider in scope.

2) I suggest rewording the title to “threshold behavior in small-scale hydrological systems: manifestation, controls and predictability”. The part on geo-ecosystems is small, not complete in its present form and – as far as I understand – beyond the scope of the paper.

3) P3250, 13: Why an ‘empirical’ threshold value?

4) 3252, bottom: the hydrosphere is missing.

5) The paper is so long as it is partly repeating things, see example at p. 3255 bottom. I think the paper could be shortened by 20 %.

6) 3258, 4: define ‘human time scale’.

7) 3258, bottom: The response at larger scale might look even simpler or even linear, as significant ‘averaging out’ could happen at that scale. Thus, the complexity at local scale does not matter that much anymore – at least if total response (e.g. stream at a catchment outlet) is studied. This should be mentioned and discussed further here.

8) 3261, bottom: It is not clear why the energy dissipation is more efficient through macropore flow. Reword this part and add 2-3 sentences. Define ‘capillary energy’.

9) In some subsection titles (e.g. 2.1.3; 2.2.3) you have ‘I’, but it is not clear why.

10) 3263, bottom: I do not see the tea-pot analogy here, as there only the energy (external force) was changed but not the boundary conditions (see above).

11) P 3267: This paragraph is not very clear. What is the trigger for sub-surface storm

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flow? Why can so much isotopically old water discharge so quickly (see $>$ 150 studies on hydrograph separation in different environments)? Which thresholds are at play here?

12) I would find it at many places throughout the paper clearer, if the authors would use ‘state’ instead of ‘regime’; e.g. 3270, bottom.

13) There seems to be an error in the section numbering at 2.3

14) 3289, top: This paragraph is not clear. I suggest deleting it or expanding on this.

15) 3292: Define ‘functional architecture’.

16) Figure 4 rather indicates gradual changes but no switches giving evidence for catchment scale threshold behavior. Did all storms at figure 5 have the same rainfall intensity such that only the total rain amount dominates?

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 5, 3247, 2008.