

## ***Interactive comment on “Exploring the interplay between state, structure and runoff behaviour of lower mesoscale catchments” by S. P. Seibert et al.***

**Anonymous Referee #1**

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Review of Seibert et al

Seibert et al, explore how well several dimensionless signatures can characterize the hydrologic response for 22 catchments in located in the Danube basin. The overarching goal of that analysis is to better understand the connections between state, structure and runoff behavior. Results indicate that certain signatures provide information about the hydrologic response from a catchment, suggesting functional similarity.

The (broad) goal of better understanding catchment similarity, using dimensionless signatures that represent our perception on underlying structural controls is in principle a relevant topic for HESS.

C1

However, I do have several concerns that for me lead to the conclusion that the paper currently does not meet the standards of HESS. The overall lack a logically and smoothly flowing structure, and details are often unclear. This makes the paper difficult and time consuming to read, wherey the scientific novelties are difficult to distil.

Before publication in HESS the following items need to be addressed:

1) I cannot find a clear main novel contribution of this paper from either the abstract or the conclusion. This may be challenging to formulate as the paper tries to understand catchment similarity for different time-scales and processes, but I do expect that there are some overarching goals.

(i) The abstract is a mess: first you state a very broad and poorly defined problem, subsequently you state many details of the analysis that are not informative is the problem is still unclear. For example how is the reader supposed to know what you mean by “extensive/additive” and “intensive/non-additive”. After you introduced the methods, your results focus on differences in functioning at different time-scales. Why didn't you introduce that you are looking at different timescales in your problem statement or methods? Your results do not clearly link to the introduction and methods part of your paper, and read like things you ad-hoc found and listed. You start stating results “Our dimensionless signatures evidently detect. . .” before the reader knows what data this comes from. This seems like an illogical and confusion order to me. Your conclusions feel like a random list of unconnected findings. Do you really need so many words for your abstract? I think you can (and should) be more to the point.

2) The introduction section lacks a logical build-up to a problem statement. Although I acknowledge that the introduction is giving a relevant overview of many challenges we face in concisely characterizing how catchments function, it reads like a long list of problems, rather than a structured introduction working defining a clear problem and working towards a clear goal.

3) Are you sure that “Question 2: Can we detect intensity controlled runoff formation

C2

as essentially a high frequency process based on low frequency data?" is a clearly defined question for the (ignorant) reader (like me).?

4) What is the coherence of Q1-Q3 beyond "testing dimensionless measures to discriminate differences in runoff generation"? If there is coherence, please formulate it such that this is clear. If there is no coherence, why would you address these three questions within a single manuscript?

5) The section "Conceptual framework and candidate diagnostics" needs to be improved. Although you list requirements of the paper in the different subsection the writing is messy. I think you should be much more to the point in clearly stating the requirements. Problems that I came across and

a. "Requirements of functional diagnostics" is mainly an overview of your perception of how the hydrology of different landscapes function. Right now the reader reads one sentence about the "requirements" but are confused by the end of the section 2.1 what the purpose of this section is. b. The requirements of "Normalization of states and response measures" and "Coherence and quality of integral storage measures" should be concisely written and to the point. c. I understand that you choose the metrics in section 2.2 based on all the requirements you have set before, but when you introduce them in this section I expect that the rationale of choosing them is clear. Currently it is not. For example "Lastly we use a normalized specific pre-event discharge ( $Q$ ) averaged across the last seven days:" is just an announcement, but leaves it completely unclear where the rationale to choose this metric comes from. The introduction of other metrics suffers from similar issues.

6) Is it logical that you provide the details of your study area only after you have discussed all the metric you use? I presume these metrics are largely based on your perception how the study catchment function. Therefore I think it would be more logical to switch their order.

7) There should be a story in your results, rather than that it is a long list of ad-hoc

C3

results you have obtained. For example you begin with the statement that "During low flow conditions, the storage estimators  $dS$  and are in most cases linearly independent." And subsequently you list the associate statistics. The logic in your story is impossible to follow (for me). Listing the how the storage metrics link to flow characteristics is fine, but please make it more read like a story.

1) The paper presents the findings as "generally applicable for meso-scale catchments". This is an extremely bold statement since only 22 catchments in a very small part of the world are used.

8) The paper is uses many words, while I am not against long papers, it does feel that with 30% less words the story can be told too.

The current version of the manuscript is not clear enough to allow me to properly evaluate the results obtained in the paper. Therefore I suggest that this paper can only be considered for HESS after rigorous rewriting and restructuring of the paper has been done. I am sure that interesting new findings are available within the results, but at this stage I can not properly evaluate this.

Detailed comments

Introduction 1.1

(i) Line 35-36: remove one of the 2 "essentially" (ii) The statement that the current crude paradigm is "Hence, identical inputs of energy and rainfall will cause an identical runoff response, if two identical catchments are in the same state." seems just wrong to me. There is NO hydrologists that think all landscapes filter climate input the same way. I.e. structural setup matters is the paradigm. (iii) Why "particularly at the lower mesoscale.?"

1.2.

(i) "Part of the confusion": which "confusion"? (ii) The section title suggests this is relevant at the meso-scale. I do not see the explanation why this is particular relevant

C4

at this scale (compared to other catchments scales).

1.3

(i) Are you sure about the statement “and equally easily be upscaled”.? I can think of a 1000 problems you can run into... (ii) Isn't “absolute storage” also difficult to work with as we can't observe it (at the catchment scale). (iii) If you introduce many terms that are not universally defined, such as “dynamic storage” and you don't explain what it means this can cause confusion/frustration for your reader. (iv) “it are the potential gradients” (not “is”)

1.4

(i) To my knowledge Budyko, 1961 does NOT talk about the Budyko curve. A more appropriate reference would be his book “Climate and life” or the 1948 publication where he first mentions the curve (ii) “Although all these measures and their normalization can in principle be determined as residuals of the water balance and from available maps, the devil lies in the details as further elaborated in section 2.1.” Can you structure your paper that we do not need such a “cliffhanger”? By the time your reader will be at section 2.1 he/she has forgotten about this statement.

1.5

(i) “mesoscale catchments”. Since this scale is central in your paper, it would be good to give a definition of this scale (since to my knowledge a universal agreement on the definition is not common knowledge). (ii) I think the paper can benefit from more explicit linkages between the research questions.

2.1

(i) be sensitive to WHICH limiting factors? (ii) strong gradients in WHAT? I presume topographic? (iii) “Capacity controlled” or “Storage capacity controlled”?

2.1.1-2

C5

(i) I had difficulty to efficiently read section 2.1.1 and 2.1.2

3.1

(i) are the scales of the maps (e.g. 1:1,000,000) relevant, or is it the grid size that matters? (ii) Why are you confident that “LARSIM (Ludwig and Bremicker, 2006) ... provides consistent areal estimates of evaporation, rainfall and snow water equivalent”?

3.2

(i) Lindsay, 2014; remove initials

4 4.1

(i) “when leaving out two alpine sites.” What is your motivation/justification here? (ii) I read a long list of correlations you found, but can you make this a bit more into a story/take the reader by its hand?

4.2

(i) What do you mean by “of the driven case”

5.5.

(i) In your conclusions I expect that you answer question you have asked before. Currently it only lists recommendations of signatures to use without any context. (ii) “to discriminate differences in terrestrial runoff production in lower-mesoscale catchments”. This might be very different for other regions with other climates and landscapes, so I do not think you can make this generalization. (iii) A reader will not (fully) understand your conclusions/outlook without reading the rest of the paper. That's not wrong, but probably not beneficial for you or the reader either.

Figures - Figure 2: if your y-axis states “relative frequency” I would not expect it unit's to be (mm/d). Or is this correct? I expect the a “Kernel density estimate” to be a non-parametric way to express the probability density function of the fluxes. - Figure 3:

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replace “rho” by its symbol and “^” by a superscript - Figure 7&11: specify the units for the event totals

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