

Interactive comment on “Hydrological hysteresis in catchments and its value for assessing process consistency in conceptual models” by O. Fovet et al.

Anonymous Referee #1

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This paper investigates how lumped conceptual models, selected (and calibrated) based on their ability to reproduce the observed runoff, also reproduce the hysteresis between runoff, saturated storage and unsaturated storage. Data collected in a small experimental catchment in France are used for this purpose. The results show that models with higher complexity better reproduce these hysteresis patterns (and therefore catchment internal processes). Hysteresis indices are proposed that could be used for model selection and calibration, provided that data are available on catchment storage dynamics.

This paper is very well written and surely of interest for the hydrology community. I

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agree with the Authors in that the purpose of hydrology is not to maximise performance measures but to correctly understand/reproduce what happens (in this case, what are the catchment internal dynamics). This is valid for practical purposes too, since models that can correctly capture the processes going on are expected to be more reliable in predicting the catchment response in conditions non observed in the past. I am definitively supporting for the publication of the paper in HESS. I have some specific comments below, but since they mostly involve additional discussion, from my side the resulting revision should be minor.

Specific comments:

Title: The analysis is done on only one (very small) catchment, while from the title I would have expected more examples.

Page 5669, Section 2.3: is the normalisation of the storage/saturation values using the minimum and maximum observed values a robust choice? How much does it depend on the record length? How sensitive are the hysteresis indices to this choice? The Authors should add one sentence here to justify that this choice is robust and/or that it has no effect on the results of the study.

Page 5670, Eq. (1): this definition for the hysteresis index is used by the Authors at the annual scale. This makes sense in this work because the storage dynamics have an annual period (see Fig. 2). Do the Author expect this to be the case in general? I would think that in other catchments there could be more cycles in one year or even a non-periodic behaviour (in arid climates). However Eq. (1) would still be valid but at the event (rather than annual) scale. If so, a sentence could be added here as a guidance for researchers willing to use the same index in different hydrological settings.

Page 5671, Eq. (2): related to the previous comment, is the choice of Q_{mid} robust? This is because I expect Q_{max} to be very variable from year to year and maybe related to short term rainfall response (flood event).

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Page 5671, lines 15-17: what do clockwise and anticlockwise hysteresis loops mean from a process point of view?

Page 5671, line 26: how does this work differ from Hrachowitz et al. (2014)? That paper is under review in WRR and has a title which could be the title of this manuscript, although more general. A sentence should be added in the introduction (and maybe also here) to clarify what are the different contributions of the two papers.

Page 5674, line 18: in Hrachowitz et al. (2014) more model structures were considered while here just four of the are analysed. What is the rationale for the choice of these four?

Page 5677, Section 3.1.3: I like this section a lot. Just a suggestion: a figure/schematic that illustrates the mechanisms leading to opposite directions of the hysteresis loops in the hillslope and riparian zone (hypothesis 3) would be very useful (here or later).

Page 5679, Sections 3.1.4, 3.1.5: maybe also the sensitivity to Q_{mid} could be explored. Do the results change if the second annual peak is chosen as Q_{max} ?

Page 5683, lines 25-27: the Authors state that "...a model able to represent the internal catchment behaviour will generate a wrong discharge value but consistent with the storage value and will be rejected in traditional calibration procedures". This is a very valid point. If the Authors could show that this actually happens in the study they made, that would be great. The model parametrisations chosen for the analysis are optimal in maximising the performance measure Eq. (5) (page 5674, lines 23-26). It would have been very interesting to find out whether non-optimal parametrisations result in better modelling of the hysteresis.

Page 5685, line 25: please recollect what are the four periods mentioned here.

Figures 7 and 8: just a suggestion: the years could be associated to the points in the graphs (e.g., "03-04", "10-11") so that the relationship with the other figures can be seen explicitly.

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Figure 9: please indicate the direction of the loops.

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