

Reply to interactive comment on “Does the simple dynamical systems approach provide useful information about catchment hydrological functioning in a Mediterranean context? Application to the Ardèche catchment (France)” by Referee#2, Claudia Brauer

M. Adamovic et al., January 2015

In the following, the reviewer comments appear in black italic and our answers are provided in blue.

General:

Note: for brevity, I shorten “simple dynamical systems approach” to “sdsa” and e.g. “page 10725, line 4” to “25-4”.

1. Does the paper address relevant scientific questions within the scope of HESS?

Yes. The sdsa is an elegant new method and very powerful if it works. Many people try it and some succeed. It’s good to get some examples in the literature showing when and where it does yield satisfactory results - and when and where it doesn’t.

2. Does the paper present novel concepts, ideas, tools, or data?

Yes, this paper gives valuable new insights into the sdsa, even though it is mostly a new application of an existing method.

3. Are substantial conclusions reached?

Yes.

4. Are the scientific methods and assumptions valid and clearly outlined?

Yes.

5. Are the results sufficient to support the interpretations and conclusions?

Yes.

6. Is the description of experiments and calculations sufficiently complete and precise to allow their reproduction by fellow scientists (traceability of results)?

Yes, although the ET and P rescaling procedure could be clarified.

7. Do the authors give proper credit to related work and clearly indicate their own new/original contribution?

Yes.

8. Does the title clearly reflect the contents of the paper?

I think the title could be adapted to better fit the contents. You didn’t investigate in depth whether the sdsa “provides useful information about catchment hydrological functioning”. I can imagine that that is what you set out to investigate, but before being able to answer that

question, you had to analyse if the sdsa would work at all and that's what most of the paper is about (which is sufficient). You do get back to the question on hydrological functioning a little in the discussion, but I still think it a secondary question.

I would therefore advise to change that part of the title to "yield satisfactory results" or something similar.

9. Does the abstract provide a concise and complete summary?

Yes.

10. Is the overall presentation well structured and clear?

Yes. I always like it when Subsection headers in the Methods and Results Sections are the same, so that when I am confused in the Results Section, I can easily find the explanation in the Methods Section. You kept this symmetry nicely. (Maybe it can be further improved by choosing either "simulation" (3.2) or "simulations" (4.2) for both 3.2 and 4.2, and "Rainfall" (3.3) or Precipitation (4.3) for 3.3 and 4.3, but these are unimportant details.)

11. Is the language fluent and precise?

Yes. I found it very well-written – I never had to read sentences twice.

12. Are mathematical formulae, symbols, abbreviations, and units correctly defined and used?

Generally, yes. Some minor things:

In Eq. 18, the mean of the observed discharge Y_i^{mean} should not include the subscript

i. You could (if you like) also add "obs" to the superscript to make clear that it's the mean of the observations (although it is specified below the equation).

- In Eq. 19, you can remove the outer brackets and the brackets around the 100. Maybe also mention that the 100 is for scaling to percents.

- The Nash-Sutcliffe Efficiency is first abbreviated as NSE and later as NASH.

- c_1, c_2 and c_3 are first in small font and later in capitals.

- Are you sure c_1, c_2 and c_3 are unitless? I could be mistaken, but I think the units of some of these may depend on the values of others. I don't recommend going into details, but maybe you could mention it (if it is indeed true) and not say that it's unitless.

- Sometimes you use round and sometimes square brackets to indicate units, both in text, tables and figures.

13. Should any parts of the paper (text, formulae, figures, tables) be clarified, reduced, combined, or eliminated?

The explanation of the P and ET corrections could be shortened and clarified (see specific comments).

14. Are the number and quality of references appropriate?

Yes.

15. *Is the amount and quality of supplementary material appropriate?*

Yes.

Answer: We thank Referee#2, Dr Claudia Brauer for this positive appraisal of the paper content and for her constructive suggestions to improve the paper.

Regarding comment 8), we agree with Referee#2 that the title can be changed to the new one: We propose: “Assessing the simple dynamical systems approach in a Mediterranean context: Application to the Ardèche catchment (France)”. However, we think that it is still interesting to keep the discussion on the interpretation on hydrological processes and geology (see also comment #4 from Reviewer 1). Other minor things given in comments #6), #12) and #13) will be corrected in the newer version of the article.

Specific comments

28-23: *You mention intense rainfall events in autumn. Is this before November (the start of the non-vegetated period)? In other words, did you take these events into account in your analysis?*

Answer: Intense rainfall events occur in this region during the whole autumn (September to November). In order to choose the period for the HyMeX (Hydrological Cycle in the Mediterranean Experiment, Drobinski et al., 2014), Special Observation Period (SOP1) conducted in autumn 2012, Ducrocq et al. (2014) indicate that “The SOP1 field campaign took place during nine weeks from 5 September to 6 November. This period captures the peak climatological period of HPEs in the northwestern Mediterranean.” However, intense rainfall events also occur during the whole November month, often triggering large hydrological response as catchments get wetter (Braud et al., 2014). In our recession analysis, events that occur before November were not taken into account, in order to avoid as much as possible the distortion of recession curves by evapotranspiration.

31-17 *“Evapotranspiration is influenced by the seasonal cycle of the vegetation”: The seasonal cycles of temperature and radiation also have a large influence on ET.*

Answer: We agree with Referee#2 and the sentence will be corrected as follows “Evapotranspiration is influenced by the seasonal cycles of temperature, radiation and vegetation cycle, the latter being particularly marked in the Ardèche catchment.... ” .

32-2 *“which renders the study more challenging”: It also renders the study more interesting, investigating if the sdsa can be used for practical (operational?) applications.*

Answer: We agree with Referee#2 and the sentence will be modified as “...which renders the study more challenging and interesting as operational networks account for a large fraction of the available discharge data in many regions”.

32-6 “we need discharge data that are not influenced by human activity, as Kirchner’s method assumes mass conservation.” Human influenced catchments can still be used for mass conserving studies, as long as you have quantitative information about abstraction fluxes or hydropower reservoir storage.

Answer: We agree with Referee#2 regarding the human influenced catchments. Unfortunately, such data was not available for the specific purposes of our study. The section will be modified as follows “...The latter are obtained from the national Banque Hydro web-site (www.hydro.eaufrance.fr) and Electricité de France. Unfortunately, numerous dams and hydro-power stations are located in the upper parts of the Ardèche and Chassezac catchments (Fig. 1). These dams are also used to regulate the water level throughout the year, in particular to ensure a sufficient discharge in the river for recreational use in the summer period. Data to reconstruct natural discharge at the hourly time step were not available. Thus we had to discard several gauging stations located downstream of the dams in order to apply the simple dynamical system approach to data where the water balance is closed.” We have recently obtained information about input daily discharge from the nearby Loire catchment that was used to reconstruct “natural discharges” at daily time steps (Noël, 2014). This data could be used for model comparison at daily time step in a distributed hydrological model based on the simple dynamical system approach (Adamovic, 2014). Results were more realistic than when using raw data, especially in terms of performances such as PBIAS and NASH on log of the discharge.

The trouble with using catchments with reservoirs for the sdsa is that the assumption of a unique storage-discharge relation will not hold: there are many possible combinations of catchment storage and discharge because discharge depends largely on dam operations and not on catchment wetness. Of course this limitation will reduce the applicability of the method in practice.

Answer: We agree with this comment of Referee#2. This point will be added in the discussion (section 5.1.2)

32-13 *How was discharge measured? A photo of the gauging station could be nice to get an idea of the measurement circumstances (if you like). A discharge of 200 l/s (the lowest Q in Fig. 6, multiplied with 90 km²) can still be measured accurately at some gauging stations. Do you have any idea of the uncertainty associated with these observations? If you would be able to draw uncertainty bands around the observed discharge in Fig. 6, the reader would get an idea of how far off the model is. This is especially useful when logarithmic y-axes are used. Maybe as an estimate of discharge uncertainty, you could assume a fixed stage height measurement error and see how it propagates in the stage-discharge relation (just an idea).*

Answer: Discharge is measured using stage measurements and stage-discharge relationships established using gaugings. The configuration of the stations with large river beds, natural river sections (no weirs) and not many gaugings make the uncertainty on discharge values quite high. In a first attempt to quantify this uncertainty, a methodology called BaRatin (BAYesian RATInG curve) (Le Coz et al., 2014) has been used for the Ardèche catchment

(Horner, 2014) providing the most probable stage–discharge relationship and the associated 95% uncertainty. Then, the propagation of all the sources of uncertainty in hydrographs has been done resulting in quantiles 2.5% and 97.5%. The results are still preliminary, but are shown on Fig 1. The figure also shows that the model behaves quite well especially in autumn and spring conditions and that discharge uncertainty is particularly large.

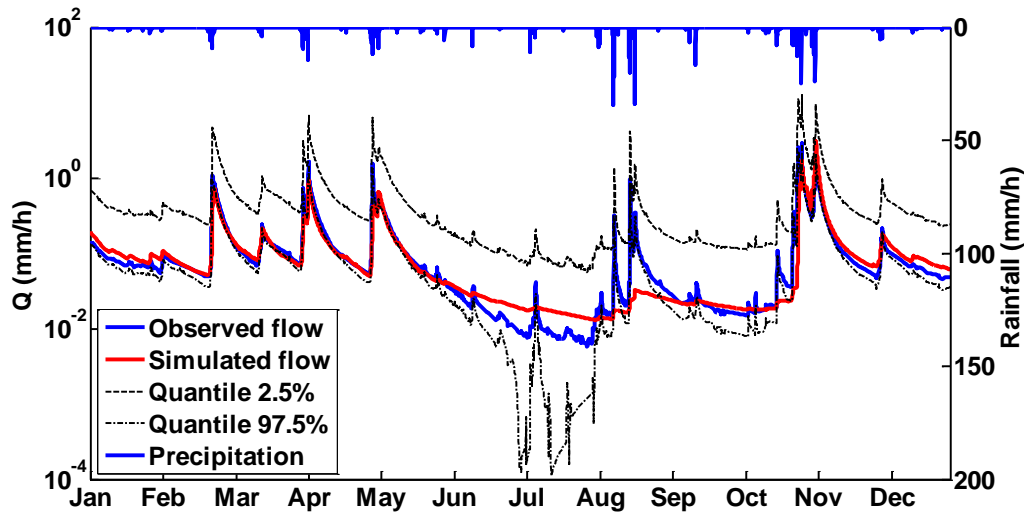


Figure 1. Series of simulated hourly hydrographs (red) for the Ardèche at Meyras (#1) catchment for the year 2004, compared with observed discharge (blue). Dashed lines correspond to the quantiles 2.5% and 97.5 %.

32-29: How many rain gauges did you use? What was the rain gauge density?

Answer: There is only one rain gauge located in the Ardèche at Meyras catchment that was used in this study. It can be also seen in Fig. 1 in the article. The Ardèche catchment is quite well covered by operational rainfall networks and research networks (see Figure 2 of Braud et al., 2014). Unfortunately, this was not the case for the four catchments, studied in this paper. There also exists kriged hourly rainfall within the OHM-CV observatory (Boudevillain et al., 2011) but only for selected events. So we had to use the SAFRAN reanalysis at the 8x8 km² to get data for all the catchments.

33-11: Can you justify the assumption that potential ET is equal to actual ET?

Answer: This point was also raised by Reviewer#1 and we provide here the same answer that the one provided for its comment 2). We would like to highlight one point which was probably not fully clear in the paper presentation. In fact we assume that $AET = \alpha_{AET} * K_C ET_0$ where α_{AET} is the scaling AET factor provided in Table 3 of the original paper. While this scaling factor is assumed to be constant throughout the year, hourly variation and seasonal variations of AET are considered. We agree that a mean annual value of α_{AET} is probably too coarse, because strong seasonal variations in AET signal are expected due to the seasonal variations of ET_0 and vegetation activity. However, the Turc (1951) formula only provides annual values of AET. The method of Thornthwaite and Mather (1955) cited by Gudulas et al.

(2013) provides monthly estimates of AET and could be a way to improve our simulations. Many studies discussed the role of actual evapotranspiration in autumn and winter periods.

For example, Boronina et al. (2005) found that in Mediterranean Cyprus actual evapotranspiration was close to potential rate during the November-March period since there was always water present in the air and soils. In other seasons he argues that evapotranspiration probably occurs from the groundwater table too.

33-28: Does the water content in the air matter for ET reduction?

Answer: When detailed models such as Soil Vegetation Atmosphere Transfer (SVAT) models are used to compute actual transpiration or evaporation, vapor pressure deficit is taken into account in the computation. Therefore it has an influence on possible reduction of AET. But this cannot be taken into account in the simplified approach proposed in our paper. Only air humidity is taken into account in the computation of reference evapotranspiration ET_0 , leading to higher ET_0 if the air is drier.

34-13: Could there be other causes for the non-closure of the water balance? Is it possible that there are other terms that are not accounted for, such as groundwater flow into/out of the catchment, groundwater or surface water abstraction, etc? How certain are you of the catchment sizes you estimated? Over-/underestimation of the catchment size could of course also lead to an under-/overestimation of the specific discharge.

Answer: In the studied catchment, there is no regional aquifer. So water balance closure problems due to groundwater boundaries being different from the topographic boundaries are unlikely to occur. Another cause of possible failure of water balance closure is agricultural uptake, which is not known to us for the examined catchments. Regarding the catchment sizes, we think that catchment sizes correspond mostly to the hydrographic network even though the geology is quite heterogeneous.

35-18: When reading this the first time, I was surprised that you doubted the precipitation as well. You explained the problems with ET in detail, but did not mention the problems with P until the explanation in the discussion (starting in 53-23). I may have read over it, but maybe (a summary of) this discussion could be mentioned earlier.

Answer: This remark will be implemented in the article and mention of possible rainfall underestimation by SAFRAN will be included sooner in section 2.2).

37-7: Is catchment #1 “accidentally right” or do you have reasons to have more confidence in this catchment than in the other catchments? What do you think causes the mismatch in #2, #3 and #4 and the match in #1?

Answer: The catchment #1 is used as a representative catchment in this study mostly due to the good precipitation estimation with local data. The raingauge, as can be seen in Fig.1, is located in the middle of the catchment, and thus probably better captures average whole-catchment precipitation. Other catchments have no local raingauge station within the catchment boundaries (#3) or there was lack of data for certain period within the years (#2

and #4). Using the SAFRAN reanalysis in these catchments however, water balance has not been closed. This led to the rescaling analysis for catchments #2, #3 and #4.

39-9: Being able to estimate $g(Q)$ from Q observations when P and ET are zero is extra advantageous in your case, because the corrections to P and ET are multiplicative, so this analysis does not depend on the rescaling you used.

Answer: This is a useful point, although the rescaling does have some slight effect on $g(Q)$. Recession analysis does depend only on discharge time series. However, the selection of points that are retained in the analysis will depend on rainfall thresholds. As rainfall is modified due to rescaling, the points used in the $g(Q)$ estimation are not exactly the same when rescaling is applied, leading to slight differences in the $g(Q)$ parameters.

39-23 “we avoided the vegetation period for the estimation of the $g(Q)$ function”: Does this introduce a bias towards the peak? Is it reasonable to assume that the behaviour of the catchment in a very wet state is similar to the behaviour in an average or dry state? A short back-of-the-envelope calculation: in Fig. 5, the $\ln(Q)$ of the lowest bin you used for the regression analysis is at about -1.5 . That amounts to $\exp(-1.5)=0.22$ mm/h. If I then look at Fig. 6 or Fig. 3, that means that only a limited section of the hydrograph is used for the regression analysis. I can imagine that eliminating summer and not using the scatter in the lower discharge regime are necessary for the application of the method, but I think it is important to mention the possible consequences of this decision.

Answer: We agree with Referee#2 that the selection of the low-vegetation period as well as the use of thresholds in the data binning implies that only some parts of the hydrographs are sampled. It is likely that the catchment behavior in wet state cannot be really considered as a similar to that in the dry state. This can be clearly seen in the not so-good modeling performance in the summer period. There, the model does not succeed to reproduce hydrographs probably due to the lack of soil antecedent moisture conditions which are usually present in low-vegetation periods. In addition, as mentioned in the paper (46 25-26 to 47 1-4), we tried to estimate the $g(Q)$ function for vegetation and low-vegetation periods, as well as by considering all the data (see details in Adamovic, 2014), and the C_3 coefficient was generally positive, which certainly shows that results are influenced by evapotranspiration. Wittenberg and Sivapalan (1999) applied a stratified recession analyses, depending on the vegetation state, to catchments in Australia and proposed a method to also retrieve evapotranspiration. Their approach can be used to improve our analysis. This reference will be added in the revised version of the paper.

40-17: Why did you chose a quadratic function? Based on Fig. 5 I would choose a linear relation, eliminating already one parameter.

Answer: We fitted also linear relation to the binned means. However, quadratic parameter C_3 was statistically significant ($p < 0.1$) and thus a quadratic function is kept as a representative function for fitting in the article. Melsen et al. (2014) concluded in their work that a two-parameter model is reasonable able to capture high flows but they fail to describe the low flows. In our analysis we therefore used the three-parameter model where the third parameter C_3 is essentially related to the low flows in order to capture the catchment behavior in that flow regime.

41-11: When I read this the first time, I wondered how you determined the ranges. Of course, 10,000 can be a small number when the parameter range you choose is very large. You do mention how you got to these ranges later, but I think it's good to mention it shortly in Sec. 3.5 as well.

Answer: We agree with Referee#2, and will modify the manuscript accordingly.

46-15: The scatter is large in log space, but small in linear space. Very small fluctuations at low discharges, caused by small variations in the storage-discharge relation (hysteresis?), may appear more substantial than they really are.

Answer: We agree with Referee#2. Apart from already mentioned reasons in the paper (46-15), the small variations could also come from the significant discharge diurnal cycle that is mentioned in the paper (40 1-3). These variations could be due to the diurnal cycle of transpiration of riparian vegetation for example. We also recognize the fact that the log space gives more weight to small variations which are not really important for "real life" applications.

47-4: Just out of curiosity: I had the problem that in dry periods, the modeled storage volume was very small and $Q+ET$ exceeded S . I had to limit Q and ET to avoid negative storage. Did that happen in your catchment as well?

Answer: We did not have to limit Q and ET to avoid negative storage since we dealt with a discharge in our study.

49-24/26: If you plot the curves with the altered parameters in a $(Q, -dQ/dt)$ -plot, do you see that changing the value of c_3 leads to similar values of $-dQ/dt$ at high $-Q$, but different values of $-dQ/dt$ at low Q ? The location of the line could explain why you only see a difference during low flow periods.

Answer: Referee#2 is right. The location of the line explains why there is only a difference during low flows.

51-7 “not overparameterized”: I’m not sure I agree completely. I suspect that the parameters are highly dependent. Did you plot response surfaces of the outcomes of the Monte Carlo simulation to investigate this? I don’t think you have to show it in your paper, but you may want to inform the reader of the outcomes.

Answer: Here, when saying not overparameterized we mean that the model obtained using recession plots from data, agrees and fits well within the chosen parameter range used in the Monte-Carlo analysis. We also agree that the way we have done our curve fitting, the three parameters values will depend on each other.

52-12 “representative of Mediterranean catchments”: Is this really true? I would expect that the Ardèche is much wetter than the average Mediterranean catchment. And, as you see, the drier the catchment becomes, the more difficult it is to apply the sdsa.

Answer: Referee#2 is right. We propose to modify the text as follows “... the Ardèche catchment representative of Western Mediterranean catchments”. Those catchments have intense rainfall events in autumn and dry summers. Moreover, the Ardèche has also a mountain influence with snow in winter, which makes it not fully representative of Mediterranean catchments.

We also agree with the Referee#2 that the drier the catchment becomes, the more difficult is to apply the sdsa as in summer periods in the Ardeche.

52-19 “more arid”: Maybe change this to “less humid”. Annual rainfall of 1400 to 2100 mm is far from arid in my opinion.

Answer: We agree with the Referee#2. This has been implemented in the article.

56-2 “however”: I think this word should be left out, as your conclusions are not in contrast with mine. In fact, they point in the same direction: the sdsa works when it’s wet enough. The Hupsel Brook catchment receives about 800 mm rainfall annually and the runoff ratio is much lower than in the Ardèche.

Answer: We agree with the Referee#2. This has been implemented in the article.

Table 3: In 53-25 you say that “SAFRAN is known to underestimate precipitation”. Why did P at catchment #3 decrease after correction? Can you justify this correction?

Answer: SAFRAN is known to generally underestimate precipitation in mountainous regions. However, SAFRAN rainfall is estimated based on so-called “symposium regions” which are assumed to be climatologically homogeneous. And rainfall from one symposium to the other can be quite different. If those regions are not well delineated, this may lead to incorrect estimation of rainfall amounts, including rainfall underestimation. Moreover, catchment #3 is particularly small, so very local factors are more likely to be more important.

Table 6: It is striking that the year-to-year variation in NSE is very large, with some very good results. For operational purposes, this can be a challenge. After a year with good results, people can come to trust the model, which then fails completely the next year.

Answer: We agree with the Referee#2. This is something that is going to be mentioned in the article too.

Figure 6: I am surprised that the peaks in August are underestimated, even though the discharge (and therefore storage) in July is overestimated. Can you offer an explanation? Does this happen in more of your runs? And if so, what does this mean for practical applications? I can imagine that for water managers this is the most important peak of the year to simulate well.

Answer: We thank Referee#2 for this interesting remark. Discharge underestimation in August and overestimation in July is seen in other years too. After the May rainfall event the system is emptying slowly leading to the discharge overestimation in July and thus later discharge underestimation probably due to the lack of antecedent moisture in August. May be there is a bypass flow phenomenon which is not captured by the model. This also points out that the model is not so recommendable at current state to be used by water managers in summer period. However, the model has perspectives to be used for flash floods.

Figure 7: In catchments #1, #2 and #3 the inferred precipitation is often high (up to 250 mm when the “observed” is zero. Do you know when this occurs? When Q is small and a small fluctuation in Q has a large effect on the modeled storage? And why does it not happen at #4?

Answer: Referee#2 is correct. Precipitation overestimation in vegetation periods can happen when Q is small and a small fluctuation in Q (possibly due to measurement error!) has a large effect on the modeled storage. This happened in catchments #1, #2 and #3. We think that this is not the case for catchment #4 where discharge fluctuations in summer periods are probably not so frequent since there have been not so many precipitation events as it can be seen in Fig. 6.

You often refer to the sdsa as “the Kirchner method” (29-28, 32-2, 32-635-14, 35-17,37-25, 35-14, 35-17, 37-25, 48-9, 52-2, 52-11, 55-21, 55-36, 56-10, 57-20 - I may have missed some). As James Kirchner is one of the authors, I think it would be more appropriate to call the method “simple dynamical systems approach”.

Answer: We agree with the Referee#2. This has been implemented in the article.

Technical corrections

Some sections contain many short paragraphs of only a few sentences. Perhaps sometimes paragraphs could be joined to keep the “flow” of the reader (e.g. 39-11, 38-15, 39-25). But this is a matter of taste of course.

Answer: This remark will be taken into account in the final version of the article.

31-4: Historical data have shown > Historical data show?

[Answer:](#) Corrected in the article.

32-3: “discharge data. The latter” > “discharge data, which”

[Answer:](#) Corrected in the article.

33-7: double bracket after “(#3)”

[Answer:](#) Corrected in the article.

33-8: “we also use” > “we also used”

[Answer:](#) Corrected in the article.

33-10: “using Penman-Monteith formula” > “using the Penman-Monteith formula”

[Answer:](#) Corrected in the article.

37-26: “in-consistency” > “inconsistency”

[Answer:](#) Corrected in the article.

38-23: Is “differentiating” the appropriate term here?

[Answer:](#) Corrected in the article as : “ dQ/dS can also be expressed as a function of Q , following Kirchner (2009) as:”.

42-9 run>ran

[Answer:](#) Corrected in the article.

42-13: “spatial-temporal” > “spatial”. You don’t have to mention temporal variation, because the point you want to make concerns spatial variation only.

[Answer:](#) Corrected in the article.

47-28 “explanation to” > “explanation of”.

[Answer:](#) Corrected in the article.

55-14: “9 year” > “9-year”.

[Answer:](#) Corrected in the article.

Table 2: You can remove “Crop coefficient” from the Table, as it’s already in the caption. You could add the periods (e.g. “Jan.-May”) belonging to each period.

[Answer:](#) Corrected.

Catchment name	K_c initial (Jan.-Apr.)	K_c mid_season (May-Oct.)	K_c late_season (Nov.-Dec.)
The Ardèche at Meyras (#1)	0.74	0.94	0.79
Borne at Nicolaud Bridge (#2)	0.73	0.96	0.80
Thines at Gournier Bridge (#3)	0.68	0.94	0.75
Altier at Goulette (#4)	0.62	0.97	0.75

Table 2. Weighted average crop coefficient for each examined catchment per growing stage

Table 3: This Table is somewhat confusing. Maybe it would help to make the numbers for your final estimate of P, ET and Q (the ones you actually used in the model) bold.

Answer: Both referees highlighted that Table 3 should be clearer. Therefore, we divided this table in two parts, one table providing the information about main terms of water balance equation (P, Q, C, AET, ET₀, K_cET₀) and the second table that gives details about coefficients when using flux scaling and corresponding variables (AET_{TURC}, T, P_{TURC}, C_{TURC}, C_n). They are also better introduced in the manuscript as proposed by Referee#1.

Table 5: You can remove “Non-vegetation period” as it is already specified in the caption.

Answer: Corrected.

Catchment name (ID)	C₁	C₂	C₃
The Ardèche at Meyras (#1)	-3.74	0.65	-0.2
Borne at Nicolaud Bridge (#2)	-4.08	0.74	-0.15
Thines at Gournier Bridge (#3)	-3.71	0.72	-0.13
Altier at Goulette (#4)	-3.80	0.82	-0.02

Table 5. Parameter values for the examined catchments for all non-vegetation periods (2000-2008).

Table 9: You can remove “Lower/upper bound” as it is already specified in the caption.

Answer: Corrected.

Parameters	C₁	C₂	C₃
Parameter range	[-1] – [-6]	[0.1 –1]	[-0.001]– [-0.5]
The range of “behavioral” values	[-3.5] – [-4.5]	[0.1 –0.9]	[-0.001]– [-0.25]
Reference (from recession plots)	-3.74	0.65	-0.2

Table 9. Comparison of the chosen parameter range and parameters obtained from non-vegetation periods for the Ardèche at Meyras (#1) catchment.

Table 10: You can simplify this Table by moving “SAFRAN rain” to the caption, remove the words “Catchment” and move the catchment names to a column in front of the performance measures.

Answer: We simplified the Table 10 as suggested by the Referee#2.

Catchment	Performance	Operational	Rescaled P	Rescaled P and AET
Borne at Nicolaud Bridge (#2)	NASH	0.45	0.65	0.67
	NASH log	0.58	0.70	0.61
	PBIAS	42	14.2	0.75
Thines at Gournier Bridge (#3)	NASH	0.36	0.50	0.55
	NASH log	0.79	0.62	0.78
	PBIAS	-13.8	22	0.98
Altier at Goulette (#4)	NASH	0.54	0.79	0.74
	NASH log	-4.90	-2.99	0.18
	PBIAS	49	23.65	-0.29

Table 10. Model performance for three examined catchments over the whole examined period (2000–2008); Comparing the original operational data and rescaled precipitation and evapotranspiration data.

Figure 3: “julian days”>“Julian days”. I would actually prefer months on the x-axes, because you don’t use Julian days in the rest of the paper. The Q, ET and P are missing on the y-axes. You don’t need to show the x-axis for the top two plots as they are the same as in the bottom plot. Could you indicate the non-vegetated period in this Figure?

Answer: We agree with the Referee#2 that in Fig. 3 rather months than Julian days should be presented since we used non-vegetation periods in our analysis. Therefore we also colored non-vegetation period in blue as suggested by Referee #2.

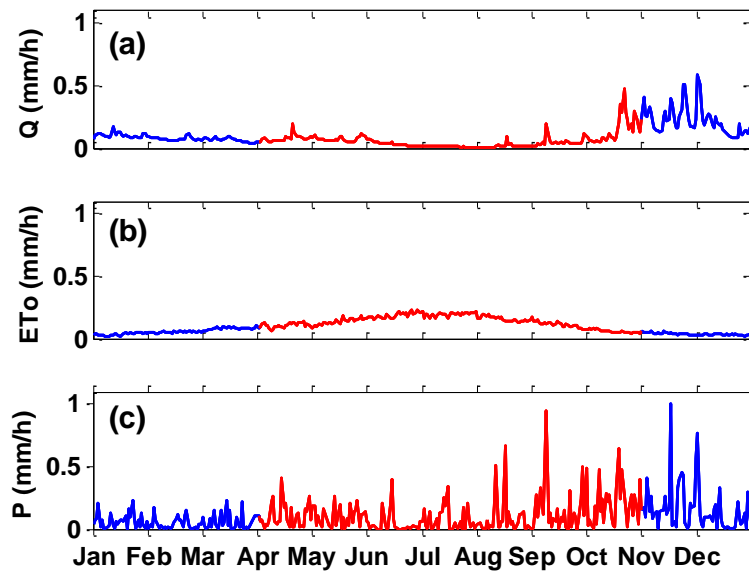


Figure 3. Average hourly discharge (a), reference ET0 (b) and rainfall (c) in [mm/h] at the Ardèche outlet for all months between 2000–2008. (b) and (c) are calculated from the SAFRAN reanalysis. In red: vegetation period; in blue: non-vegetation period.

Figure 5: I prefer log axes to plotting $\ln(Q)$, like you did in the other Figures, so it’s easier to compare to the hydrographs (for example to see which part of the range of Q is used). You also used mm/hr instead of mm/h.

Answer: We agree with Referee#2 that it would be also useful to plot the Fig. 5 on log axes. We did this for the plot on the left whereas for the plot on the right we kept the $\ln(Q)$. We have also corrected the units (mm/h).

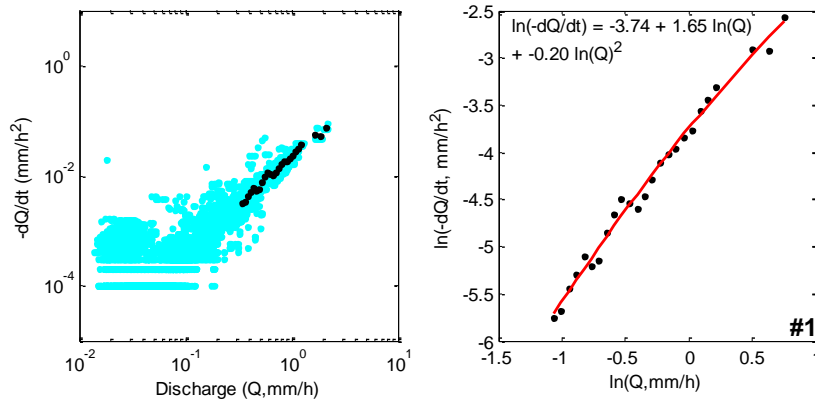


Figure 5. Recession plots for the Ardèche at Meyras (#1) catchment for all non-vegetation periods between 2000 and 2008; (left) Flow recession rates ($-dQ/dt$) as a function of flow (Q) for individual rainless night hours (blue dots) and their binned averages (black dots). (right) Quadratic curve fitting with binned means.

Figure 6: The right y-axis label “P (mm/h)” is missing. I would prefer a second panel with the discharge shown in linear space to see how good or bad the fit in June and July is for “real life” applications.

Answer: The Fig. 6 has been also modified. As a supplement to this figure we plot another figure here in linear space to show the fit in summer periods for “real life” applications.

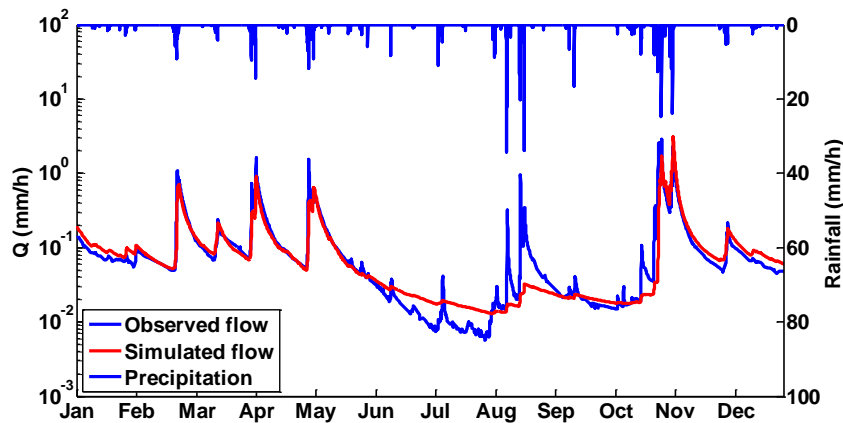


Figure 6. Series of simulated hourly hydrographs (red) for the Ardèche at Meyras (#1) catchment for the year 2004, compared with observed discharge (blue).

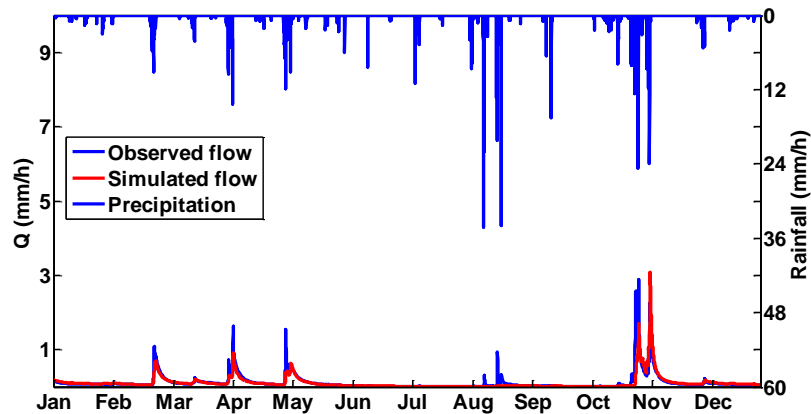


Figure 6-1. Series of simulated hourly hydrographs (red) for the Ardèche at Meyras (#1) catchment for the year 2004, compared with observed discharge (blue) in linear space.

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