

Interactive comment on “Investigation of dominant hydrological processes in a tropical catchment in a monsoonal climate via the downward approach” by L. Montanari et al.

L. Montanari et al.

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To begin with, we would like to thank the Referee for the concise, straight and clear review he has provided. As it emerges from his review in fact, he has made a careful reading of our paper, focusing on all the main points of the research, which is substantially well resumed in the first part of his review.

In details we think that the principal Referee’s concerns are: firstly (1) the applicability of the simple rainfall-runoff models at daily scale, as proposed and developed in the paper; secondly (2) the requirement of a more detailed description of the methodology adopted to obtain the four bucket model. Both these points are well posed by the Referee and their pertinence is not a matter of question.

As far as point (1) is concerned, we agree that to well reproduce daily runoffs, com-

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plex dynamics and non linear processes must be considered too. At this finer time scale in fact, averaging effects occurring in monthly and annual scales are less effective and more complex and structured models are required, in order to reproduce the hydrological processes, with particular regard to soil moisture simulation and thus to soil saturation and runoff generation. This paper's aim is to understand the hydrological behaviour of Seventeen Mile Creek basin, i.e. to individuate the most important processes in the catchment with regards to runoff generation. This is considered to be an important issue in ungauged basins, as it permits to group catchments by their hydrological behaviour, thus allowing regionalisation techniques to be applied. In this way discharge predictions become possible also in ungauged catchments, where results obtained from hydrologically similar basins may be considered for the study case as well, at least as hypotheses concerning the main processes of runoff generation, which is the base of any modelisation. It is our opinion that, to fulfil this task, parsimonious model structures have to be sought, as they are, if carefully developed, a powerful means to investigate hydrological behaviour of catchments. Following the downward approach for example, as explained by this paper, additional complexity can be added to the model only when required, thus leading deeper and deeper investigation into main hydrological processes. Moreover, the choice of simple model implementations allows one to control each single structure's effects with regard to the modelling of the principal hydrological processes of the catchment. Following this procedure, model calibration and parameter setting become easy and fast, without requiring both heavy computer routines for minimising object functions and incurring in equifinality problems. Our model development in particular is believed to be efficient in reproducing the catchment behaviour as far as the runoff generation is concerned, because it is possible to individuate the runoff components generated by each of its structures, thus understanding the main hydrological processes occurring in the catchment. Nevertheless, we agree with the Referee affirming that of course more complex models, providing a more detailed simulation of soil saturation, may give a better reproduction of the observed discharge series, but may also obfuscate the real dynamics

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occurring in the catchment. This effect can be attributed to model building and to its calibration. As the complexity of the model is increased, both in process simulation and in spatial description of the basin, but the catchment knowledge remains limited, some hypotheses concerning the occurring hydrological processes need to be made, not necessarily in accordance to the real nature of the catchment, as this might remain unknown due to restricted information one has.

The second point risen by the Referee was already discussed in our previous Reply. As we wrote before, we agree with the Referee's remark, thus we will provide a more detailed description of the procedure adopted to obtain the four bucket model, if we are allowed to revise the paper. In order to provide a more readable paper this details will be summed up using a table.

We will hereafter address some of the detailed comments reported by the Referee.

Page 166: line 5 - 10. We recognise that these lines might be misleading, thus we try here to make some concepts clearer. The best model structure, in our opinion, is subjective in the sense that it depends on the catchment characteristics and on its hydrological main processes. Therefore we did not assume that the runoff generation process in the catchment was the saturation excess, but we deduced it from the initial analysis reported in the paper. This procedure is followed during the all paper, using the downward approach. Each consideration and each structure added in the model are in fact first proved in advance by this method and no hypothesis is drawn, without being demonstrated first. The downward approach is useful in any case of catchment process investigation, while the model choice may vary from case to case. Thus we agree with the Referee that the downward approach may also lead to a different hydrological model structure (depending on the analysis findings) and that this concept need to be strengthened in the paper.

Page 169. We are of the same mind with the Referee, considering that the single bucket model could be already discarded in the lights of the considerations of the previous

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analysis, thus we must underline this concept in the paper. Nevertheless, we would like to keep this paragraph, because it provides a sort of completeness in the model development: not in all study cases in fact it can be discarded, it is instead important to start from this simple structure.

Page 170. The choice of the number of buckets in the model “is identified by maximizing the fit to the observed runoff at annual and monthly time scales”, as cited in lines 3 and 4 of page 170. As this description can appear unclear we will add a line stating that this procedure is iterative: one starts from one bucket, verifies the fit to the observed runoff at annual and monthly time scales, adds a bucket at time and verifies the fit to the observed runoff at annual and monthly time scales, and so on...remembering Occam’s razor concept: prefer the simplest structure among those which give similar result accuracy.

Page 170. We disagree with the Referee at this point. Even if the identification of the two runoff components (delayed runoff and groundwater flow) is indirect, they present extremely different characteristics and above all they describe phenomena having very different time responses, which can not be grouped together. This difference appears also in the modelisation, as the parameter choice depends on this time response and the two resulting components take place with different lead times.

Page 171, line 10. The overprediction of the model B4DG emerges also from Figure 11: the dot line (model simulation), in the highest discharge values, that is the one having little percentage of exceedance, assumes higher values than the continuous one.

Page 171, line 13. We agree with the Referee that this consideration must be cited also in the paragraph 2, in the study catchment, otherwise it appears a contradiction.

Page 172, line 12. We completely agree, the sentence will be reformulated.

Page 172, line 27-28. We are in accordance with the Referee regarding the mentioned

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simplicity of the model, which might be a cause of the inaccuracy in reproducing some extreme values. Nonetheless, we believe that the sentence in line 3-9, page 173 gives some further explanations as far as our model choice is concerned. Two main characteristics of the model are there mentioned. The first is a limit of the model: due to its simplicity, the model may fail in some extreme value reproduction, because it does not simulate the runoff generation processes with accuracy. The second instead is a model's quality, regarding the easy calibration of the parameters, that it requires, which implies a direct control on the parameter effects and on the model structure.

Page 173 (we think it is 173 and not 26), line 26. The Referee is right with regard to the saturation runoff and to the delayed runoff, but we do not agree with him concerning the groundwater flow. This latter component in fact lasts for the whole year, as shown in Figure 4, but it is almost irrelevant if compared to the other components. This analysis is not extensively reported to make it more readable, but, if we are asked to, we will provide further description.

Page 175, line 3-8. As for previous observation, if it is believed that it is necessary for the comprehension and that it does not make the paper too heavy, we will add a more detailed description and some related Figures.

Page 176. Following the Referee's suggestion the conclusions will be reformulated, mentioning the limits of the model, as delineated above. As far as the result analysis is concerned, we would like to underline that it is also conducted on daily results, by calculating the Nash and Sutcliffe (1970) efficiency, whose values are reported on Page 171 and 172.

Page 177, line 3. The comment is accepted.

Page 177, line 23-25. The auspicated regionalisation process is not applied in this paper, even so there are a lot of examples in scientific literature which report satisfying results obtained by application of regionalisation techniques and which encourage investigation toward this direction. Of course further research needs to be done in

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order to develop a regionalisation technique utilising the downward approach and the model development procedure here described, nevertheless we think that this way is very promising. The downward approach here presented in fact can be followed for any ungauged basin, until the data availability permits it. After that, the only practicable way to proceed is to individuate similar catchments, as far as some geomorphologic and hydrologic characteristics are concerned (slope, topography, annual rainfall, etc...) and then to apply regionalisation techniques. Thus we agree with the Referee that, individuating similar catchments to regionalisation purposes, we need to take into consideration all the aspects mentioned above, which influence and contribute to runoff generation.

Page 188, Fig 4: It will be added in the Figure caption.

Page 194. The Referee is right: we need to explain why mean monthly discharges are divided by mean annual precipitation. First of all mean values are chosen in order to give general behaviour representation of the runoff processes occurring in the catchment. Secondly, our purpose at this point is to underline the different runoff generation processes throughout the year (intra-annual behaviour), thus we divide the mean monthly runoffs by the mean annual rainfall, in order to immediately individuate the portion of annual rainfall converted into runoff during each month and to visualise the months which give the highest contributes. The trend is more or less the same during all the considered years. In our opinion this procedure of reporting the results is dense of meaning and leads to a lot of reasonings, without distorting the represented results. The monthly runoff values in fact, can be obtained by simply multiplying the dot values in the graph by the annual rainfall, but the plot shape will not change.

Page 195 and 196. The comment is accepted, “percentage” will be substituted by “frequency”.

Page 196 and 197. Legend Text: It will be “groundwater flow”.