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Hydrology and Earth System Sciences Discussions

Interactive comment on "Neural network emulation of a rainfall-runoff model" *by* R. J. Abrahart and L. M. See

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The reviewers have provided a number of helpful insights that will be incorporated into the revised paper. Their suggestions for improving the publication of our reported findings are much appreciated.

1. The revised paper will provide further information on the conceptual model. This will support a better understanding and interpretation of our results. The improved description and additional references that have been provided will be included.

2. The nonlinear equation will be expressed in the suggested non-dimensional format. This will reduce the number of reported experiments to two; the need to respond to questions about the optimal nature of intermediate models is thus obviated. Sections 4 and 5 will as a result be shorter.

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3. The revised paper will contain two experiments; modelling with and without the b parameter. This parameter is used to represent a non-uniform spatial distribution of responses and thus constitutes an important non-linear hydrological driver. The power of a neural solution to provide non-linear outputs without the benefit of an important non-linear input is thus being tested.

4. Experiments 1-3 modelled similar relationships and had the same output predictand. Experiment 4 modelled a different sort of relationship; it had a different output predictand and presented a different set of challenges. The observed skills and deficiencies cannot as a result be compared or contrasted in a direct manner with our other reported experiments. The revised paper will be modified to highlight the similarities and differences of our revised models in a clearer manner. Target function plots will be produced for a series of different throughput combinations and the nature of the modelled relationships discussed at an earlier stage since such figures will hold the key for interpreting our results.

5. This paper considers minor non-linear effects at the lower end of the b parameter; the effect of increasing the range of this parameter would produce an intensification of reported differences but it will not alter our final conclusions. The main point is that substantial differences will arise in terms of what can or cannot be encapsulated even with minor or trivial non-linear relationships. Further experimentation on the power of a neural network to capture the full range of complex non-linearities that could be contained in the conceptual model would be a useful endeavour and could be tested at a later point. This issue will be clarified in our paper and the diagram that has been provided will be used to denote the extent to which our reported findings are valid.

6. Explicit details and tighter explanations will be provided on minor items: “precipitation” will be changed to “effective precipitation” throughout the paper; a sigmoid transfer function was used in the reported models; the type of transfer function(s) that were used in the two earlier papers will be listed in our paper and their operational differences highlighted; the rationale underpinning particular assumptions related to the

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conceptual model and input and output dataset ranges will be spelt out.

7. The need for more experiments of a similar nature that seek to settle fundamental issues within the hydrological sciences will be discussed in more detail in our revised paper. It is implied that our findings are well established; but the reported content of two earlier papers would suggest that such properties are not accepted as a matter of fact in certain quarters. There is an ongoing debate about the acceptance of neural networks in the hydrological sciences and it is essential that disputed findings are challenged; contentious issues must be resolved in a transparent and unambiguous manner.

8. The paper will be modified to explain that major differences exist between the diverse types of non-linear hydrological process involved in: (i) a model that converts rainfall into storm runoff without considering time distribution or other essential components e.g. infiltration, evapotranspiration, sub-surface flow; and (ii) the earlier reported studies that sought to model flow hydrographs in a time domain (with higher lead times in some cases). However, the purpose of our paper is not to compare models, but to deliver a clarification of concepts since the reported experiments are focused on the questioned capabilities of a neural network to model non-linear relationships. No direct comparison was intended between the earlier WLTF and later MLIN models; such solutions were however of a similar type although the functional processes that were being modelled are of course different. The reported research seeks to establish a fundamental point and in disputed situations we would argue that it is better to start from the simplest opening position: modelling without a temporal component. The next step is to test time series forecasting models in a similar manner and thus increase the number and level of detailed proofs that can be shared with interested parties throughout the hydrological sciences.

9. Important issues surrounding the adoption of complex models will be clarified. It is accepted that simpler models could well produce similar output scores but the real purpose of optimisation is not to develop an optimal model. It is to improve the quality of the solution and on this occasion the selected model was one that sought to maintain

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and not restrict important hydrological relationships. The need to search for a parsimonious solution equates to a different form of optimisation and one in which important properties, such as robustness, might be lost; indeed, a parsimonious solution is a solution with as few parameters as possible for a given quality of model, but the nature of what does or does not constitute an important set of qualities remains a fundamental operational management decision.

10. Modelling involves a number of assumptions but neither the non-linear nature of hydrological processes, nor the importance of modelling from an operational point of view, in which observed measurements are required for decision making purposes, is being questioned. It is instead contended that the existence of substantial assumptions must be recognised and reported, and reflected in conclusions drawn from individual studies.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 4, 287, 2007.