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Hydrology and Earth System Sciences Discussions

Interactive comment on "A novel approach to parameter uncertainty analysis of hydrological models using neural networks" *by* D. L. Shrestha et al.

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We are very grateful to Anonymous Referee 1 for valuable comments. We carefully studied the comments and our responses to them follow. We will revise our manuscript in accordance with the comments as far as possible.

Our replies are in bold.

This paper introduces a ANN approach to estimate the uncertainty in modelled discharge based on the HBV model. Interestingly, the paper aims at modelling prediction intervals rather than estimating a standard deviation as proxy for uncertainty. Latter is only relevant if the pdf is Gaussian, however, as is clear from the results, the predicted

uncertainty in discharge is not Gaussian.

I regret somehow that the paper only discusses briefly on the current literature on uncertainty estimation techniques as a whole range of techniques exists and during the last years, many papers have been published that compare (or introduce) techniques for uncertainty propagation or estimation.

We agree. In the revised version, we will extend the literature review on uncertainty estimation techniques used in rainfall-runoff modeling especially.

Furthermore, the paper lacks a profound discussion: in current version, the results and discussion part is extremely short, and I believe that a more in depth discussion on when the model is making the largest or smallest errors could be given (this is not summarized in one sentence). In the whole discussion part (and basically the setup of the paper) different ANNs could have been compared, where each ANN is based on different input data. This is currently only restricted to Rt-9a, Qt-1 and deltaQt-1. Maybe other input variables may have been a better choice (this may be learned from an indepth study of the results of the proposed ANN: where did it really get off, and what variables may have reduced this error?).

We have mentioned in the original paper at page 1690, 20 that "Several structures of the input data including lagged variables were considered". We have tested ANN with different possible input combination based on correlation and average mutual information analysis. However we presented only the best results. In the revised version of the paper we extend the discussion considering several structures of the ANN.

Further minor remarks (XXX.yyy stands for Page XXX, line yyy):

1678.1-2: ": : : developed to replicate a time consuming Monte Carlo (MC) simulation by using an Artificial Neural Network (ANN) for the assessment : : :"

Corrected.

1679.6: ": : :still lacks a well-established convergence criterium to : : :"

Corrected.

1679.10: "In addition, the MC based : : :"

Corrected.

1680.1: "estimating two quantiles" instead of "estimating the two quantiles"

Corrected.

1684.5: ": : : MC simulations, an ANN will: : :"

Corrected.

1686.1: ": : : values lie within: : :" instead of ": : : values lies within : : :"

Corrected.

1687.4: adding a table that summarizes these statistical properties would be beneficial

Added.

1687.13-14: it is not clear to me why you first use an automatic calibration procedure after which you manually fine tune the parameters.

If the parameter ranges are not properly specified during the automatic calibration, it is often the case that automatic calibration gives the solutions which might be near the border of the parameter ranges. Therefore re-calibration of the model was done with the extended ranges of the parameters. Sometimes automatic calibration gives the parameter values which do not represent the physical process well in all situations. It is necessary to compare the hydrograph in all situations and even have to check for example soil moisture condition etc. In case if the calibrated parameters do not represent the physical process, then fine-tuning of the parameters is needed.

1687.18: ": : : Nash and Sutcliffe : : :" . Please add reference to the Nash and Sutcliffe paper (in references, Sutcliffe is also misspelled)

Corrected.

1689.12: typo: sensitivity instead of sensitive

Corrected.

1689.16: "learn the functional relationship: : :"

Corrected.

1689.25: "a predictive ANN model."

Corrected.

1689.16: "learn the functional relationship: : :"

Corrected.

1690.9: define (formula) the average mutual information

Done.

1690.6-19: not clear what exactly should be seen and interpreted from figure 6

We updated this paragraph.

1690.27: ": : : Furthermore, the derivative of : : :"

Corrected.

1691.12: ": : : verification of the HBV model : : :"

Corrected.

1691.17-23: mention that number of hidden layers is one.

Added.

692.7: ”The ANN based : : :” (also remove the dash between ANN and based as everywhere in the paper this is not written)

Corrected.

1692.10-16: according to the text, the ANN reproduces the MC simulations 'reasonably well'. I do not agree: errors of 15 m3/s are found!. Also figure 9 is not convincing: if one looks at this figure (and also looks at the differences between ANN and MC prediction intervals), one sees large differences. I would appreciate that the figure goes with additional information such as an average error. Furthermore, a more detailed analysis could reveal some of the shortcomings (when are the errors large?, can this be contributed to one of the input variables to the ANN? What if alternative input would have been given to the ANN?)

We updated the paper adding more detailed analysis. We reformulated the mentioned sentence to "ANN reproduces the MC simulations uncertainty bounds reasonably well except for some peaks".

Figure 3: this figure is too small. The difference between observed and simulated cannot be seen in detail. I would suggest to at least break the figure down in two panels: one for the calibration period, the other for the validation period.

Done.

Figure 4: no need for a coloured y-axis.

Corrected.

Figure 6: no need for colours

Corrected.

Figure 9, top panel: figure is too small to recognize anything. Observed dots are masking too much. Again I would suggest to break figure down in several panels.

Figure 9 is broken down in several panels.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 6, 1677, 2009.