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Hydrology and Earth System Sciences Discussions

Interactive comment on "Comparative assessment of predictions in ungauged basins – Part 1: Runoff hydrograph studies" *by* J. Parajka et al.

J. Parajka et al.

parajka@hydro.tuwien.ac.at

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Author response to review 1

We would like to thank the reviewer for her/his positive, constructive and very helpful comments on the manuscript. We have addressed the comments as follows (our response is in italics):

This is a well-written paper which makes a significant contribution to the literature. The only concern I have is with the intercomparison of Nash-Sutcliffe Efficiency scores across widely differing environments. I think this topic needs to be mentioned by the authors in their paper. The paper contains a wealth of valuable information, which the authors have made accessible and digestible. I would expect it to lead to many

follow-up studies, and to provide useful guidance for hydrological modelling studies and applications.

Thank you for the very positive comments. In response to the concern about the Nash-Sutcliffe Efficiency (NSE), we have added a section in the discussion part of the manuscript (for more details, please see our response to specific comments).

Specific Comments

P379 Line 24 "The predictive accuracy was then described by the Nash-Sutcliffe efficiency (NSE, Nash and Sutcliffe, 1970) of daily runoff." This is a limited method of assessing model performance. It would be useful to include some commentary on strengths and weaknesses of using NSE to evaluate hydrological models. The main reason for raising this issue is that the paper analyses catchments from a wide range of environments, including some which are strongly seasonal and some which are not. It is easy to get a good NSE score in a strongly seasonal catchment, even with a rather crude model. Is a high NSE score in a strongly seasonal environment a reflection of high accuracy of modelling in this environment, or an artefact of the scoring? I see no problem in using NSE to compare different methods on the same catchment, but there may be a problem of interpretation when comparing the same method on markedly different environments (e.g. section 4.5).

We agree with the reviewer that the NSE might be biased in catchments with strong seasonal regime. It will be thus very valuable, if the future studies will publish also some additional information and runoff performance measures, which will allow to further improve the comparative assessment across different runoff regimes. In response to this comment we have revised the discussion section and added following paragraph: "The predictive accuracy of different regionalisation methods was quantified in terms of Nash-Sutcliffe efficiency (NSE). Since it is a traditional performance measure used in hydrology, it has an advantage that almost all reviewed studies evaluate the predictive accuracy by using NSE (an exception is the study Vogel, 2005 that uses R2). On the

other hand, NSE is a normalized skill score that measures runoff model performance relative to a baseline model, which is in this case mean of observed runoff values. This can lead to overestimation of NSE in catchments with strong seasonal runoff regime (see e.g. discussion in Schaefli and Gupta, 2007). As pointed out in Gupta et al. (2009), a comparison of NSE across basins with different seasonality should therefore be interpreted with caution. For future comparative evaluations, we would hence suggest to use additional information and performance measures that will also enable evaluation of different parts of runoff hydrographs, i.e. peaks, times to peak (Nester et al., 2011) or event recessions. This will help shed more light on the ability of different regionalisation methods to predict different hydrograph signatures across different runoff regimes."

P380 Line 24 "Four catchment characteristics are analysed: aridity index, mean elevation and catchment area" The list contains three characteristics, rather than four. *Corrected.*

P385 Line 22. The authors use number of flow recorders as a measure of data availability. It is true that more flow recorders will enable better predictions. However, the number of gauges is a very crude measure of information availability. A set of ten gauges within a study area of 100 km2 is very different to ten gauges within a study area of 100,000 km2. Do the authors consider that the number of gauges is more useful in characterising information availability than the gauge density? (density = number of gauges per sq km). In addition, the quality of flow estimates often depends on the quality of rainfall information. If the rainfall data is very sparse, then one might also expect poor simulations. I think this is worthy of a comment in the paper, even if no information is available on rainfall data density.

We agree with the reviewer, that the number of stations is only an indirect index which characterizes data availability. We were also thinking about some way how to estimate gauge density, however we found that (from published information) it is often not very straightforward and accurate, e.g. because of unknown study area. There are also

studies (e.g. Bastola et al. 2008), which transfer model parameters from one to other country/continent, which also does not allow a proper estimation of gauge density. We would thus prefer to retain the index characterising data availability as it is.

P388 line 20 "Overall, this very clear pattern of an increase of the performance with catchment scale may be due to two reasons. The first is a trend for an increasing number of raingauges within a catchment as the catchment size increases." Why does more raingauges lead to better models? Surely it depends on the density of raingauges relative to the correlation length scale of the rainfall? It might be useful to cite Schaake (1981, see http://www.nws.noaa.gov/oh/mopex/raingage

It is indeed difficult to quantify the reasons from information published in the papers, but we agree with the reviewer that it also depends on the relation between raingauge density and correlation length scale of the rainfall. In response to this comment we have cited suggested reference and added following sentence into the section 4.5: "... a trend for an increasing number of raingauges within a catchment as the catchment size increases. This trend likely reflects the relation between raingauge density relative to the correlation length scale of the rainfall (Schaake, 1981)."

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 375, 2013.