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Interactive comment on "A comparison of regionalisation methods for catchment model parameters" *by* J. Parajka et al.

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Evaluating the overall quality of the discussion paper ("general comments"):

The paper addresses a topic, which is definitely of relevance to the hydrologic community, since prediction in ungauged basins is seen as one of the priorities in international hydrology. The paper is an extension of a former paper by the co-authors Merz and Bloschl (2004), who examined the performance of various methods of regionalizing the parameters of a conceptual rainfall-runoff model in 308 Austrian catchments. They concluded that methods of parameter transfer to ungauged basins based on spatial proximity performed better than those based on physiographic catchment attributes.

This paper builds on these results and extends them in three areas. First, the lumped catchment model from the previous study was extended to a semi distributed form in order to better account for the vertical zonality in precipitation and temperature inputs

in Austria. Second, the multiobjective calibration method used in the previous study was modified; in addition to runoff data it now also uses snow cover data for model calibration. Third, since Merz and Bloschl (2004) found that the regressions between model parameters and catchment attributes didn't perform as well as other regional parameter estimation methods, (however it was not clear to them whether this was due to the fact that the selected catchment attributes were poor hydrological indicators at the regional scale or just due to problems with the multiple linear regressions used) these methods were revisited and extended by kriging based spatial interpolation of regression residuals. Also other alternative methods that use catchment attributes for regionalizing catchment parameters and are based on similarity measures, were suggested and tested.

The treatment of the regional model calibration and parameter regionalization problem in the paper is systematic and comprehensive. The results are based on a rich database and the authors test a rich choice of traditional regionalization methods for model parameters. The paper also presents novel concepts of catchment model parameter regionalization and compares them to other methods under diverse hydrological conditions. The paper can therefore be considered as more than just a repetition of the previous paper, it can be seen as a substantial extension of it. It contains new original research results and addresses relevant scientific questions which are definitely within the scope of HESS.

The comprehensive dataset used in this study allowed for well founded conclusions on the potential of the treated methods, however one has to bear in mind, that these are model and region dependent. Nevertheless they can serve as a guide for applications of parameter regionalisation methods in other regions. The scientific methods and assumptions are clearly outlined, but since results from a huge amount of computations are presented and generalised, in some cases it may be difficult for the reader to look for very specific details. Given the large regional and computational scale of the study, inevitably expert judgment and know how had to be used, a few items will therefore

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require further clarification (these issues will be addressed bellow in the section containing specific comments). In general, however, the description of model experiments and the presented results are sufficient to support the interpretations and conclusions. The discussion of results is systematic and the authors also compared their results with similar studies.

The complete reproduction of the results by fellow scientists (traceability of results) would be rather difficult to guarantee given the specific character of the study, comprehensive database employed, huge number of simulations and expert knowledge used in the model calibration (In fact one would need to have access to the whole digital database, which was used by the authors, to the model code, its application know-how, details on the organization of the calculations, and probably also to a lot of subjective local knowledge on Austrian runoff generation conditions, which understandably cannot be given in the paper). However the reproduction of the methodology under different conditions, based on the descriptions in the paper, can be seen as realistic.

Proper credit to related work was given (maybe one or two additional citations could be added) and the authors clearly indicate their own contribution. The title clearly reflects the contents of the paper and the abstract provides a concise and complete summary. The amount and quality of supplementary material is appropriate, a few changes, which are recommended below, could add to the interpretability of results. The overall presentation is well structured and clear, the language is fluent and precise, only few clarifications will be requested in the specific comments.

Section addressing individual scientific questions/issues ("specific comments"):

p. 510, l. 24

In my opinion hydrologic regionalization could be seen as a more general term, than just transferring information from catchments to a catchment of interest, as stated in the paper. Region is a term used in geography that describes an area of the Earth,

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where some natural or human-made phenomena display similar traits. Regionalisation deals with the delineation of such regions, suggests methods to do so and also studies the diverse properties of regions (including the possibility to transfer the information).

p.511, l. 24

It could be mentioned in the review, that the study of Shu and Burn is on regional flood frequency analysis, and that the homogeneity of hydrologic response in their sense is defined through the regional flood frequency distribution (its type and parameters) and is not referring to the rainfall runoff regime in general (or its modeling by rainfall runoff models).

p. 512, l. 10

Maybe a few additional references could be included into the review. E.g. the paper Fernandez et al. (2000) may be worth considering, which describes a different methodology for the regionalisation of watershed models and their parameters, which involved the concurrent calibration of the model parameters and of the relationships between model parameters and catchment characteristics at many sites in a region. They have used a dual objective of reproducing the behaviour of observed monthly streamflows and simultaneously obtaining good relationships between the water balance model parameters and basin characteristics. The approach has led to nearly perfect regional relationships between watershed model parameters and basin characteristics. However, the use of these improved regional relationships has not resulted in improvements in the ability of the model to simulate streamflow at ungauged sites.

The study Szolgay et al. (2003) cited in the paper was preceded by a paper by Hlavcova et al. (2000), which builds on Fernandez et al. (2000). It intended to find regionally valid rainfall runoff model parameters reproducing the behaviour of observed monthly streamflows at individual sites and in the region as a whole as well as using multiobjective calibration. This method was than further extended in Szolgay et al (2003), which was mentioned in the review.

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FERNANDEZ, W. - VOGEL, R.M. - SANKARASUBRAMANIAN, A.: Regional Calibration of a Watershed Model. Hydrologic Sciences Journal, Vol. 25, No. 5, 2000.

HLAVCOVA, K. - SZOLGAY, J. - CISTY, M. - KOHNOVA, S. - KALAS, M.: Estimation of mean monthly flows in small ungauged catchments. Slovak Journal of Civil Engineering, Vol. VIII, 2000, No. 4, 21-29.

p. 512, l. 28 - 30

I would suggest to consider including a few conclusions at the end of the introduction which would evaluate and indicate tendencies in the development of model parameter regionalisation followed by a bit more detailed outline of the paper.

p.513, l. 1-30

Merz and Bloeschl (2004) contains a more comprehensive description of the dataset, which was probably also used in this study. Please consider adding a few sentences on data quality in the selected catchments (antropogenic effects, closing the water balance of catchments etc.). A histogram of the distribution of catchment areas may also be considered as a useful addition and good information for the readers.

p. 513, l. 27

Were the CV values of elevation and slope used in the analysis? I was missing reference to them later in the text.

p. 514 - 520 Model calibration:

The description of the model setup and its calibration naturally contains a lot of expert know how. Please consider therefore adding a few explanatory notes or references in order to make the modelling exercise more repeatable by others:

Ţ Snow correction factor - is it a correction applied to the measured values according to a precipitation correction methodology? Is there a reference according to which the corrections were made? Do you have an evaluation of the effectivity of such a

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correction in Austria?

Ţ Applying the same parameters to the elevation zones enables to better account for spatially distributed inputs - could you please indicate in the paper to what extent had the introduction of elevation zones improved the modelling results?

Ţ The composition of the objective function contains weights obtained by test simulations. Could you please consider adding a few explanatory remarks or hints how to conduct (repeat) such an exercise? How significant is the effect of putting 10 percent weight of a calibration criterion on the overall performance of the model?

Ţ Could you please explain in the paper, why was the threshold of 50 percent of the catchment area chosen for poor snow simulation and why not a measure of a relative difference between simulated and observed snow cover?

Ţ Could you please give a bit more detailed explanation of the reason for choosing the beta function for the a-priori distribution of parameters and of choosing the same lower and upper bands for all catchments?

Ţ How adequate was the performance of the daily model in the smallest catchments used in the study?

p. 519 - 521 Regionalisation methods:

In the description and grouping of the regionalisation methods I suggest indicating more formally, which methods were already used in the previous study, which were modified for this paper and which were added as new. E.g. a table containing such information together with the main features of the methods could be useful in this respect.

A general comment on the possible problems arising from using catchments of different size on model parameters regionalisation could be useful (e.g. 50 km radius in large catchments vs. small catchments, using nearest neighbours of different sizes, etc.).

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p. 519, l. 28

Could you please give some information on the minimum and maximum number of cases which were included in the local georegressions? How many cases were required for the development of a regression equation with three independent variables as a minimum?

p. 521, l. 3

I do have some problems to follow the arguments in favour of the “perfect” diagnostic case. What does the similarity of model parameters mean from the regionalization point of view - does it imply catchments similarity (and if, than in which sense (attributes, climate?)), cannot it just mean similarity by chance? I would argue in favour of considering leaving this case out from the comparison, if possible.

p. 521 - 524 Performance of regionalisation methods

The CDF and the simple statistical measures were useful for the evaluation and comparison of the overall performance of the methods. Is there a specific statistical reason why the median and the difference of the two quantiles were chosen and not the mean and variance? Reading the CDFs and comparing them may be difficult to less experienced readers, maybe the distribution of the model efficiencies could be considered as more informative? It may be rather difficult to interpret differences of the order of 0.01 in the median between two approaches from the practical point of view for the reader, in fact only the authors can see the real model performance behind these values. In some places such information on model performance in different catchments was given in the paper. Wouldn’t it be possible to complement the comparison of methods based on the model efficiency measures also by a few comments summarizing your practical experience with the overall model behaviour?

Regarding the regression methods one could also say, that the regression methods perform approximately at the level of the global and local mean (0.61/0.21 and

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0.64/0.18 versus 0.60/0.24, 0.62/0.19 and 0.65/0.19). One could also say that in the verification period the situation is even worse. What is then the real gain of accounting for regional differences by regression?

Listing of purely technical corrections:

p. 514, l.3 I suggest to change the reference IH (1999) to Flood Estimation Handbook (1999) and to drop the reference to the particular pages.

p. 528, l. 22 Please correct the reference to Merz and Bloeschl. Fig. 4 - 8 The cumulative distribution functions are a bit difficult to read in both HESSD format on screen and also if printed.

The same applies for the maps for the case one would like to compare the values of the attribute of a specific site.

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