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Hydrology and Earth System Sciences Discussions

Interactive comment on "Assessment of the indirect calibration of a rainfall-runoff model for ungauged catchments in Flanders" *by* N. De Vleeschouwer and V. R. N. Pauwels

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We want to express our gratitude to the reviewer for the constructive review. First, the general comments will be discussed. Then, the detailed comments will be addressed.

Answers to general comments

1. The authors disagree with the statement of reviewer 1 that there is no novelty in this paper. The innovative aspect of the paper (which has also been noted by

the other reviewers) is that we extrapolate information (the full density spectrum) both in time and in space, in order to calibrate a model for catchments which contain no data. This has not yet been performed, and our results indicate that the approach that we developed is promising.

2. It is not entirely clear to the authors whether the comment *'The authors should describe the methodology and outcomes more clearly. Many main topics have been left without answers'* of the reviewer is an introduction to the more detailed comments or a general statement. In the latter case the authors find the comment rather vague because it is not specified what is unclear about the description of the methodology and outcomes, and which main topics are not discussed in the discussion paper.

Answers to detailed comments

1. As noted by all three reviewers some key references are not discussed in the literature review of the discussion paper. The following references will be added to the paper in order to give a more accurate overview of published research in the context of parameter estimation in ungauged catchments:

    - Bardossy, A.: Calibration of hydrological model parameters for ungauged catchments, 25 HYDROLOGY AND EARTH SYSTEM SCIENCES, 11, 703-710, 2007.
    - Castiglioni, S., Lombardi, L., Toth, E., Castellarin, A., and Montanari, A.: Calibration of rainfall-runoff models in ungauged basins: A regional maximum likelihood approach, ADVANCES IN WATER RESOURCES, 33, 1235-1242, doi:10.1016/j.advwatres.2010.04.009, Workshop on New Frontiers of Hydrology, Rome, 30 ITALY, JUL, 2009, 2010.

- Merz, R. and Bloschl, G.: Regionalisation of catchment model parameters, JOURNAL OF HYDROLOGY, 287, 95-123, doi:10.1016/j.jhydrol.2003.09.028, 2004.
- Oudin, L., Andreassian, V., Perrin, C., Michel, C., and Le Moine, N.: Spatial proximity, physical similarity, regression and ungaged catchments: A comparison of regionalization approaches based on 913 French catchments, WATER RESOURCES RESEARCH, 44, doi:10.1029/2007WR006240, 2008.
- Parajka, J., Merz, R., and Bloschl, G.: A comparison of regionalisation methods for catchment model parameters, HYDROLOGY AND EARTH SYSTEM SCIENCES, 9, 157-171, 2005.
- Post, D. and Jakeman, A.: Relationships between catchment attributes and hydrological response characteristics in small Australian mountain ash catchments, HYDROLOGICAL PROCESSES, 10, 877-892, doi:10.1002/(SICI)1099-1085(199606)10:6h877::AID-HYP377i3.0.CO;2-T, 1996.
- Seibert, J.: Regionalisation of parameters for a conceptual rainfall-runoff model, AGRICULTURAL AND FOREST METEOROLOGY, 98-9, 279-293, doi:10.1016/S0168-1923(99)00105-7, 1999.
- Vogel, R. and Sankarasubramanian, A.: Validation of a watershed model without calibration, WATER RESOURCES RESEARCH, 39, doi:10.1029/2002WR001940, 2003.

2. References for eqs. 1, 2, 3, 4, 15, A1-A15 will be added to the paper. Eqs. 5-11 have been developed by the authors.
   - eq.1: Thibos L.: Fourier Analysis for Beginners, e-book, School of Optometry, Indiana University, 2003.
   - eq.2: Papoulis, A.: Probability, Random Variables and Stochastic Processes, McGraw-Hill, New York, 1965.

   - eq.3: Papoulis, A.: Probability, Random Variables and Stochastic Processes, McGraw-Hill, New York, 1965.
   - eq.4: Weber, D. D., and Englund, E. J.: Evaluation and comparison of spatial interpolators: Math. Geology, v.24, no.4, p.381-391, 1992.
   - eq.15: Nash J, Sutcliffe J.: River flow forecasting through conceptual models, part I: a discussion of principles. Journal of Hydrology 108: 282-290, 1970.
   - eqs.A1-15: Moore, R.J.: The PDM rainfall-runoff model. Hydrol. Earth Syst. Sci. 11 (1), 483-499, 2007.

3. The choice for the specific values of the weights at page 112 line 5 is partially subjective since the authors are not convinced that a 100% objective weight determining method is straightforward in this case. However, it would be an interesting research question to more thoroughly examine the relationship between certain catchment properties on the one hand and the donor selection process followed by indirect calibration on the other hand (see page 123 line 3-6). However, investigating this falls outside the scope of the paper. A high weight (0.3) was given to the NDId because proximity of two catchments is an important indicator for the hydrological resemblance of both catchments (Oudin 2007). The weights given to the other (catchment specific) indexes was based on the observed strength of the relationships between the spectral densities and catchment properties in scatterplots (drainage area $>$ mean local slope $>$ soil composition, landcover). This should indeed have been mentioned in this section.

4. The relative bias and relative RMSE do not have the same meaning. Model results characterised by a high systematic error will lead to both a high bias and RMSE. On the other hand model results with a high noise level and low systematic error will lead to a low bias and high RMSE. To summarize, a low RMSE implies a low bias, but a low bias does not imply a low RMSE.

5. These parameters were posed to reduce the parameter vector and thus the computational effort of its optimisation. The values for particle population size and the amount of iterations were taken over from Pauwels and De Lannoy [2011] in order to be sure that those assigned values would be realistic (correct magnitude). Because both parameters have an influence on the convergence of the algorithm but were not calibrated, this had to be checked. Convergence was the case in all calibration experiments. This last step should indeed have been mentioned in the article because now the impression is given that those values were chosen because of a high similarity between the research in this article and Pauwels and De Lannoy [2011].

6. It is unclear to the authors what the added value is of presenting the data in figures 3, 5 and 7 in table form. We believe that the results are clearer when presented in a plot.

7. The indications on the axis of figures 4, 6 and 7 will be enlarged. Figures 9 and 10 would be larger in the article format and consequently fully readable because all figures are in vector format.

8. - The indicated English errors will be corrected.
   - Page 104 line 10: *'furtherhermore'* will be corrected as well.

9. A legend will be supplied and the catchment numbers will be made clearer in fig. 2.

10. The authors are convinced that some new conclusions have been drawn from this research. More specifically, there are no studies in hydrology in which information (the full density spectrum) is extrapolated in space and in time in order to calibrate a model for a catchment for which no measurements are available. This has also been noted by the other reviewers.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 103, 2013.