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Hydrology and Earth System Sciences Discussions

Interactive comment on "Calibration of hydrological models using flow-duration curves" *by* I. K. Westerberg et al.

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The HESS(D) paper by Westerberg et al. caught my immediate attention because it had the words "calibration" and "flow duration curves" all in the title and reminded me of work I had previously carried out under the theme of "top-down" approach to modeling. Obviously I welcomed it and yet I was intrigued to discover the experiences of the authors.

I do not wish to comment fully on the technical merits of the paper at this stage, leaving it to the editor and the appointed reviewers. I may come back to this issue at a later stage in the discussion process.

(1) My first point is that I have used the flow duration curves as one of a number of metrics to both develop and calibrate conceptual models, using the top-down approach over the past 10 years, which I will describe briefly below. It is the collective experience of a whole generation of students and collaborators that the flow duration curve (FDC) alone is insufficient to fully calibrate rainfall-runoff models of daily water balance variability. The information content in the FDC is insufficient to estimate all parameters unambiguously. In the top-down approach we typically use a series of signatures, not just the FDCs, in descending order of time scale: (i) inter-annual variability of annual runoff, (ii) mean monthly variation of runoff or the regime curve, (iii) flow duration curve, and (ii) recession curve.

I have a hard time accepting the authors' contention that FDCs (alone) would be sufficient to calibrate a rainfall-runoff model of a reasonably complex catchment – maybe I misunderstand the thrust of their contribution. I discussed this with colleagues who are doing this very thing for a dozen catchments across the United States and this was the same experience they related to me. This is also my experience modeling dozens of catchments in Australia, New Zealand, Austria and the United States.

The authors may want to comment on this, and we can debate this in future discussion of this manuscript.

(2) My second point is on the claim by the authors that their use of the FDC represents a "new calibration" approach for rainfall-runoff models. In the light of the above, and what appears below, I would like them to qualify their claim.

As I mentioned above, I have been involved in a series of papers, as part of the top-down approach to modeling, where the focus is on the development of models of appropriate complexity and parameter calibration in a systematic hierarchical manner, starting at the annual scale, and progressing downward towards models of increasing complexity, as we progressively invoked other signatures of runoff variability.

The rationale for the top-down approach is outlined very well in the papers by Atkinson et al. (2002), Son and Sivapalan (2007), and especially in the paper by Farmer et al. (2003). Below I reproduce the relevant sections:

"The results of model simulations are presented in the form of signature plots [Jothityangkoon et al., 2001; Farmer et al., 2002], and also in terms of the hydrographs of observed versus predicted streamflows, and through statistical summaries. Signature plots are statistical representations of the inter-annual, intra-annual (monthly) and daily streamflow variability of the catchment runoff response. They enable us to assess how well the model is able to predict the streamflow response of the catchment without the reliance on hydrograph fitting, and moreover, can give us considerable insight into catchment response." (Atkinson et al., 2002).

"Traditional approaches to measuring the success of models rely upon some minimisation of the differences between observed and predicted runoff time series. While these have been quite effective in getting the models to mimic observed data through a process of calibration, such approaches have provided limited feedback on areas of model deficiency and sensitivity to model parameters. In this paper we adopt four key measures of runoff variability with increasing temporal resolution (i.e., temporal signatures), which we suggest can provide meaningful definitions of catchment runoff response and against which it is possible to compare model predictions." (Farmer et al., 2003)

(3) I do this to draw the attention of the authors to the congruence between the rationale outlined above in Atkinson et al. (2002) and Farmer et al. (2003) to a part of the abstract (and later the introduction section) of their paper (Westerberg et al., 2010) where they present their rationale for their use of the FDCs for calibrations in place of the actual hydrograph (time series).

"Calibrations with traditional performance measures such as the Nash-Sutcliffe model efficiency are challenged by problems including: (1) uncertain discharge data, (2) variable importance of the performance with flow magnitudes, (3) influence of unknown

input/output errors and (4) inability to evaluate model performance when observation time periods for discharge and model input data do not overlap. A new calibration method using flow-duration curves (FDCs) was developed which addresses these problems. The method focuses on reproducing the observed discharge frequency distribution rather than the exact hydrograph." (Westerberg et al., 2010)

(4) I welcome the authors' work and any further application and extension of the approach to calibration on the basis of signatures of runoff variability. However, the community will benefit more if their work is placed in perspective, drawing the similarities and differences with what has been done before, instead of claiming a totally new track to modeling or calibration, which will only lead to confusion and add to the fragmentation. This requires a more nuanced presentation than is present in their discussion paper (see below for emphasis). We as a community should make every effort to synthesize and consolidate what we have done as we move towards fresh challenges and new approaches.

(5) In this context I want to draw the attention of the authors to the PUB Benchmark Report (still under preparation). This report has adopted the "functional" approach to catchment predictions, where the "catchment function" is defined in terms of a series of signatures of variability, including the FDC. Indeed a whole chapter of this book is devoted to the FDCs. The rationale for the functional approach, which represents the synthesis I referred to above, has been described elegantly by the first chapter of the draft book, and draws heavily from a paper by Wagener et al. (2007). Even if the Benchmark Report is not yet available to the public, Wagener et al. is available.

(6) As I said before I greatly appreciate the valuable contribution this paper makes, because in my opinion, it contributes to an existing framework, and moves the debate in a positive direction and in a constructive way. Therefore, in spite of my comments above I look forward to participating in the discussion of this paper through the excellent opportunity that HESS(D) offers to the hydrologic community.

I also want to add that if you can bring FDCs within the GLUE formalism, then there is every possibility that other signatures can also be brought into it, opening the way for new and insightful ways to not only calibrate models, but also develop and test new model structures. This will be a formalizing of the top-down approach to modeling, and the development of flexible model structures (the work of Fabricio Fenizia and colleagues), but also advancing the cause of PUB.

(7) Another potential benefit of the use of the FDCs (and other signatures) is that this can also be adapted for use in ungauged basins, with any model being constrained by regional estimates of the FDCs (and other signatures), provided assumptions of regional similarity are valid. Such an application will advance the cause of “behavioral modeling”, the subject of another discussion paper, i.e., the opinion paper by Schaefli et al. currently in HESS(D).

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