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Comment on hess-2021-413

Anonymous Referee #1

Referee comment on "On constraining a lumped hydrological model with both piezometry and streamflow: results of a large sample evaluation" by Antoine Pelletier and Vazken Andréassian, Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2021-413-RC1, 2021

General comments

This paper describes the additional value of piezometric data in the calibration of a lumped, conceptual hydrological model (GR6J), in addition to the use of streamflow data. This approach is tested on 107 catchments in France variying in size, climatic conditions and hydrogeological characteristics. Not suprisingly, the model performance in simulating streamflow hardly improved or even deteriorated, although the authors honestly indicate that they see this as 'truly disappointing'. The model performance in simulating groundwater levels is promising and parameter stability increased. The composite calibration strategy proposed in this paper enabled a generally good model performance on both streamflow and piezometry without too much trade-off compared to the original calibration only using streamflow data.

Overall, the paper is well written and presents interesting insights in the use of additional (groundwater) data for hydrological model calibration tested on 100+ catchments. The authors generally use informative figures to illustrate their results. Several issues need attention such as the derivation of the objective function for groundwater levels, the comparison of original and composite calibration for both streamflow and piezometry, the choice of the transformation function for the exponential (groundwater) store level and the structure of the last discussion section and conclusion section. These and other specific and technical comments can be found below.

Specific comments

- L55-56: Conceptual and physically-based models are mentioned representing less and more physical processes in a model. Shouldn't empirical hydrological models be mentioned here as well, since these present the 'lower' end of the 'physics spectrum'?
- L118-120: This sentence is not very clear and needs to be reformulated. Furthermore, it is doubtful whether the apparent content generally is valid. At least when compared to simpler, conceptual hydrological models, it will be more difficult to match simulated and observed time series of physical variables in physically based models, since more parameters are fixed based on observations - hence reducing the degree of freedom in

the calibration - and calibration processes are cumbersome and time consuming.

- L192: Which climatic data are meant here and which climatic data were used to calculate the potential evaporation?
- L208-209: How was the relative importance of each hydrogeological formation assessed?
- Table 2: The variability of the mean annual potential evaporation is quite low (range of 600-792 mm), where I would expect a much larger range for France given the diversity in climatic and geographical conditions. Could the authors explain this a bit more?
- L268-269: How has GR6J been calibrated; which optimization method has been used? And which data and time period(s) were used in this stage of the study?
- L291: Why has equation (2) been used to transform the exponential store level to the normalized piezometric level? Which alternative relations have been investigated and which criterion has been used to select this particular equation?
- L300-304: The conversion of equation (4) to equation (5) does not seem to be correct. The observed and simulated piezometric anomalies can each be expressed according to equation (1). Combining equation (1) and (4) does not result in equation (5). For instance, one would expect to see the observed and simulated standard deviations and the average simulated value in equation (5). This does not necessarily disqualify ZError as expressed by equation (5) and used in the model calibration and validation, but the derivation of equation (5) should be reconsidered.
- Figure 7: An alpha value of 0 was discarded since no groundwater level simulation is 'performed' in that case. Do you mean that the model could not generate an exponential store level? The alpha value only is a weight is the composite objective function and hence should not influence the model simulations, isn't it? In addition, I think it will be interesting and relevant to compare the groundwater level simulations with the original calibration as well. Now validation results for the original and composite calibration are only compared for streamflow (e.g. Figure 16), but a similar comparison for groundwater levels seems to be relevant as well. What is the improvement in groundwater level simulation when taking piezometry into account in the calibration compared to the traditional approach where only streamflow data are used?
- L430-474: Section 4.6 (Synthesis) and section 5 (Conclusions) both contain conclusions and partly discussion. Try to strictly separate discussion of limitations, comparison with other studies and generalization issues (Discussion) from the main findings linking to the objective of this study (Conclusions). In addition, the discussion section can include some more comparisons with previous studies (e.g. studies mentioned in the introduction), where the value of data in addition to streamflow data for calibration and validation of hydrological models has been assessed.

Technical corrections

- L4: 'lumped rainfall-runoff models'; this term indicates the spatial aggregation scale of the model, but does not give information on the extent to which physics are incorporated in these models (i.e. empirical, conceptual and/ or physics-based models).
- L8: 'groundwater levels' instead of 'groundwater level'.
- L15: 'complex water cycle underground processes'; what do the authors mean with this term?
- L20-21: 'hydrogeological' (line 20) and 'geological' (line 21); has this distinction been made on purpose or should a consistent term be used?
- L69: 'a rare example of a conceptual model' instead of 'a rare example of conceptual model'.
- L86: 'used a groundwater reservoir'?
- L94 and elsewhere: 'anthropogenic' instead of 'anthropic'.

- L129: ‘with few streamflow measurements’ instead of ‘which few streamflow measurements’.
- Figure 1: Some colours are hard to distinguish (e.g. for the Bresse graben and the Bièvre moraine).
- L206: ‘10% of precipitation falls’ instead of ‘10% of precipitations fall’.
- Table 2: What is the definition of catchment yield?
- L250 and L251: ‘precipitation’ instead of ‘precipitations’.
- L264: ‘an approach’ instead of ‘a approach’.
- L287: ‘piezometric relative anomalies’ or ‘normalized piezometric levels’?
- L287: What is the meaning of z?
- L305: ‘[-∞;1]’ instead of ‘]-∞;1]’.
- L394: ‘as the result of fluxes between topographic catchment’; what is meant here?
- L402: ‘small’ instead of ‘weak’.
- L469-471: This explanation is hard to follow, please try to rephrase.