Hydrol. Earth Syst. Sci. Discuss., 10, C3693–C3701, 2013
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Hydrology and Earth System Sciences
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Discussions

Interactive comment on "The influence of conceptual model structure on model performance: a comparative study for 237 French catchments" *by* W. R. van Esse et al.

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Received and published: 1 August 2013

The authors thank Dr Ross Woods for his positive and constructive comments on the manuscript. We agree with most of the points of view he expressed and we explain how we will modify the text to account for his comments.

Main points

1. 5459L22 "Several examples of fixed models' failures have been described in the literature" It would also be useful to cite the work using diagnostic signatures to infer model structure, since these papers can be used to infer that some model structures

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are inconsistent with observed hydrological responses (inconsistency between data and model structure is a type of model failure). Some recent examples I am familiar with are Euser et al (2013) and McMillan et al (2011).

Reply: We agree that the inconsistency between model internal states and observed variables may be a cause of model failure. These references were added and shortly commented.

2. 5459L27 "Given that model structural errors are often a first-order source of uncertainty," This statement needs some clarification, referencing or further argument to support it. My (admittedly highly selective) personal experience is that the greatest contribution to uncertainty in model output is from uncertainty in precipitation amount, and the second greatest is from the conceptualisation and quantification of subsurface ('slow') flow characteristics. Of course the authors may have quite a different view, and I would encourage them to explain briefly why they see model structural errors as so important.

Reply: The respective roles of model structure, model parameters or input estimation in total modelling uncertainty are often difficult to determine without extra information and may change from one catchment to another (see e.g. Kuczera et al., 2010). We agree that precipitation is a first-order source of error in many cases, especially in catchments with a large gradient and/or sparse gauging networks. Yet we stress that strong performance losses may come from erroneous model choice or conceptualization (see for example the large performance differences between model structure shown in the manuscript or in previous studies, e.g. in Perrin et al., 2001).

We agree that our sentence is not supported by evidence, the sentence will be rephrased.

3. 5462L5 Are any of the 237 catchments significantly influenced by lakes or snow fields? If not, this would be helpful to state. It would also help with interpretation of the scope of the classification proposed here. As an example, in cold climates with mainly

winter precipitation, we expect low winter runoff coefficients (precipitation is mainly stored as snow) and high summer runoff coefficients (river water sourced mainly from summer melt). This would confound the interpretation of seasonal runoff coefficients in terms of groundwater.

Reply: Catchments were selected to have limited snow influence (in particular, no catchments selected in the French Alps or Pyrenees). Lakes also have a limited impact on these catchments. This will be clarified in the text. The classification was designed for the present selection of catchments, where the runoff coefficients are on average higher in winter than in summer. Other classifications may be more appropriate in different climates. We will clarify this in the paper.

4. 5462L8 There is potential redundancy in using both permeability and the ratio of seasonal runoff coefficients. I would expect both of these to contain information on groundwater dominance. Do the authors have evidence to show that they are distinct, and therefore both needed?

Reply: We agree with this point. The idea was to use the ratio of seasonal runoff coefficients as an indicator that combines climate and catchment characteristics where permeability only reflects a catchment property, however, the contrast between these two indicators on models SF08-12 is small and does not lead to different conclusions (as mentioned in comment #10). In the revised paper, we omit the permeability classification and use solely the ratio of seasonal runoff coefficients because the results are clearer.

5. 5462L16 Where you say "when runoff compared to rainfall is high in summer," do you mean relatively high in comparison to winter? I guess the wording is difficult, because the highest values of the ratio are only 0.24. Or are you presuming a particular type of climate seasonality for all 237 catchments? (e.g. wet winters and dry summers?)

Reply: Yes, the sentence was referring to seasonal differences in the runoff ratio. We will rephrase the sentence to make it clearer.

6. 5463L22 “Potential evapotranspiration is systematically corrected with a calibrated ratio to fulfil the water balance.” I have several questions about this. Does this means of correction imply that there may be interdependence between Ce and other parameters? (since the water balance depends on actual ET, and actual ET depends on both the PET and the model parameters). Does this correction mean that the rainfall data is assumed to be more reliable than the PET data? Does it also mean that there is no significant inflow or outflow of groundwater across the catchment boundaries, or that the groundwater flux parameter (F for GR4J) is known?

Reply: Getting the right water balance in the model is a key issue. Using correction factors for inputs (rainfall or potential evapotranspiration), catchment area, or underground exchange functions are among the functions commonly used depending on the role each component has in the total uncertainty. Using more than one correction factor will generally cause correlations between them, therefore a choice has to be made. In SUPERFLEX, the choice was made to use a correction factor for PET, because (1) it is hypothesized that the main bias lies in the estimation of the potential evapotranspiration; (2) multiplication factors to the potential evapotranspiration are commonly used to account for different land use types (e.g. the “crop factor” in the FAO – Penman Monteith equation); and (3) it was conceptually simple, though possibly less efficient than other correction function (like underground exchanges, see e.g. Le Moine et al., 2007). We did not find significant correlations of this parameter with other model parameters, as this is the main parameter compensating for the water balance in the model (e.g. the SUPERFLEX structures do not assume any groundwater flux parameter). This aspect will be clarified in the description of SUPERFLEX.

7. 5468L25 “the lag-function and the interception and riparian zone reservoirs do not increase model performance on average, which questions their usefulness.” That must surely depend on the purpose of the modelling. If the purpose of the model is to evaluate the impact of changing the vegetation from trees to grass, then having an interception reservoir may be extremely useful, even if it is not as accurate as other

models. On the other hand if the purpose of the model is to generate synthetic flow data, then I agree those features may not be at all useful.

Reply: We agree that this comment should be less general. It will be modified accordingly.

8. 5469L11- In discussing Figure 4 or later in the Discussion section, it may be useful to refer to place these results in the context of the recent paper by Parajka et al (Parajka, J., Viglione, A., Rogger, M., Salinas, J. L., Sivapalan, M., and Blöschl, G.: Comparative assessment of predictions in ungauged basins – Part 1: Runoff hydrograph studies, Hydrol. Earth Syst. Sci. Discuss., 10, 375-409, doi:10.5194/hessd-10-375-2013, 2013.)

Reply: We thank the reviewer for this reference. We will make a link to the cited study, as they use some descriptors common to ours.

9. 5469L25 "Figure 4c shows that model structures with two reservoirs in series (SF03–SF07) perform better on impermeable catchments than on semi-permeable or permeable catchments." Yes, but does a different model structure do a better job for semipermeable or permeable catchments?

Reply: Actually, all structures perform better for impermeable catchments (except for SF11 that performs equivalently for impermeable or permeable catchments). However, the difference is more significant for structures SF03-SF07 (and GR4H). The sentence will be rephrased to make this point clearer.

10. 5470L8 Does the classification by RC_S/W lead to markedly different conclusions than the classification by permeability? It is interesting that for SF04-07 the contrast between impermeable/permeable in Fig 4c is almost identical to the contrast between groundwater/direct runoff in Fig 4d.

Reply: See reply to comment #4.

11. 5474 The Conclusion does not comment on the relationship between catchment

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properties and selection of appropriate model structure(s), and this leaves me wondering how to apply the authors' findings. What did the authors conclude from their assessment of Figure 4c/4d? Are some model structures better suited to some types of catchment than others? Given a new catchment, how would the authors select a model structure? What more needs to be done to answer this question?

Reply: This is a very interesting question. We conducted additional analysis to try and find the best a priori model structure for the catchment set, using the following approach:

(1) Splitting the catchment set into subsets using the three indicators (omitting permeability) and the three classification categories for each of them, thus creating 27 subsets.

(2) For each subset, identifying the model structure that provides the best average performance. This structure can then be viewed as the “a priori” model structure recommended for catchments with the corresponding characteristics.

(3) Applying this "a priori" model structure to all the catchments in the subset and computing the average performance of this a priori model structure on the full subset.

The results are shown in Fig. 1 below. It is an extension of Figure 6 and includes now the average performance of the entire data set when using the a priori model structure for the 27 subsets. It appears that the simple indicators used here are not sufficient to reliably select a model structure a priori. Model performance on average is not higher than when using GR4H and the stability of the model results has worsened (less consistent models). Neither do the results show that this a priori selection is useful for particular catchment types (none of the models excel in any of the sub-samples). This is not to say that the a priori selection of model structure is not possible, but further research is needed (e.g., along the lines of Fenicia et al., 2013).

There are (at least) two possible explanations for this: (1) either these catchment properties are not sufficient to fully characterize the hydrological behaviour of the catchment, and/or (2) establishing a predictive link between catchment properties and model structure requires more sophisticated approaches than the one tested here.

12. 5458L16 "disturbances in low flow measurements." Not sure what this means

Reply: We meant that clear problems in low-flow values could be identified in the observed time series. This will be clarified.

13. 5459L12 "apply it on his case study" I would say "apply it on their case study"

Reply: This will be corrected.

14. 5462L8 I think the Wetness Index would be better termed Humidity Index or Aridity Index (its reciprocal), to avoid potential confusion with Topographic Wetness Index.

Reply: We will change to Humidity index throughout the article to avoid confusion.

Cited references:

Fenicia, F., Kavetski, D., Savenije, H. H. G., Clark, M. P., Schoups, G., Pfister, L. and Freer, J. (2013), Catchment properties, function, and conceptual model representation: is there a correspondence?. Hydrol. Process.. doi: 10.1002/hyp.9726.

Kuczera, G., B. Renard, D. Kavetski and M. Thyer (2010). There are no hydrological monsters, just models with large uncertainties! Hydrological Sciences Journal: Submitted manuscript.

Le Moine, N., V. Andréassian, C. Perrin and C. Michel (2007). How can rainfall-runoff models handle intercatchment groundwater flows? Theoretical study based on 1040 French catchments. Water Resources Research 43(6): W06428, doi: 06410.01029/02006WR005608.

Perrin, C., C. Michel and V. Andréassian (2001). Does a large number of parameters enhance model performance? Comparative assessment of common catchment model structures on 429 catchments. Journal of Hydrology 242(3-4): 275-301, doi:210.1016/S0022-1694(1000)00393-00390.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 5457, 2013.

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Interactive Comment

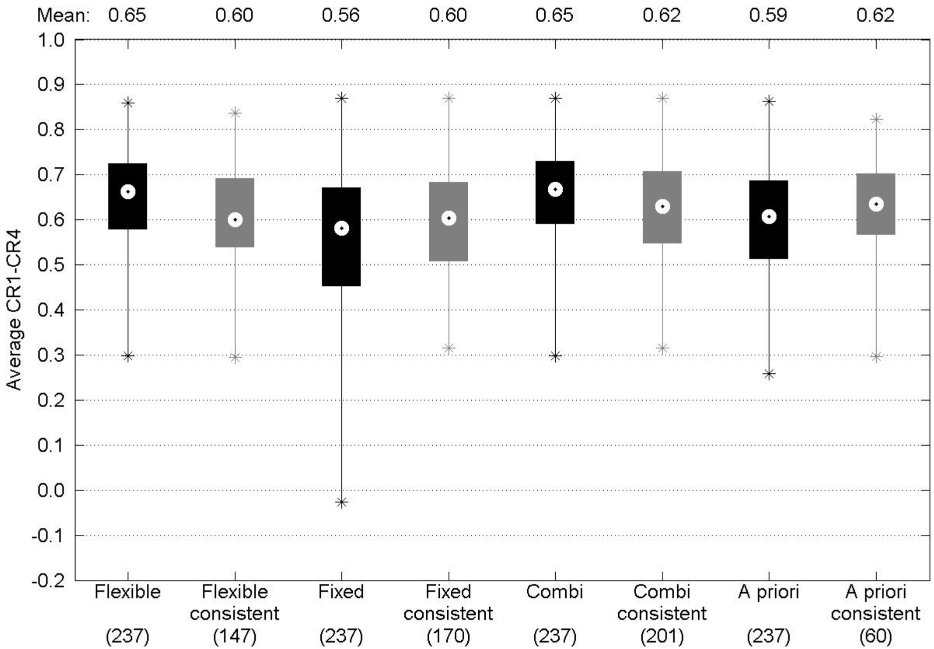

Fig. 1. Distribution in average performance in validation for the flexible, fixed, combined and a priori approach. See Figure 6 in manuscript for more explanation.

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