

Interactive comment on “Robust estimation of hydrological model parameters” by A. Bárdossy and S. K. Singh

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General comments

The paper introduces a very interesting, sensible and potentially useful methodology for fitting hydrological models to data. This remark is made against the background of the difficulty of obtaining a uniquely best parameter set (using conventional least squares or likelihood techniques) which is robust to errors in the input and output data and the catchment model specification. The method used adopts the Nash-Sutcliffe coefficient (obtained from the comparison of observed and modeled streamflows) as the metric to determine the cluster of ‘best’ and most ‘robust’ parameter sets, after perturbing the input and output time series many times by multiplicative errors. The cloud of vectors (points) in the multidimensional parameter space is each tagged with the metric. It

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turns out that the ‘innermost’ points in the cloud, whose position is determined by Tukey ‘depth’, produce robust and similar responses when applied to segments of the original data, but do not necessarily contain the one with the highest metric, although the average over the deepest subset of a small proportion of the many points is highest.

Although potentially computationally demanding, the authors have adopted an approximate method for partitioning the cloud of fitted parameter vectors with hyperplanes, which enables efficient counting of points to either side of a chosen point to determine its ‘depth’. This means that the methodology is a feasible one for determining ‘good’ parameter sets (the deeper the better) of a fitted hydrological model. The authors are to be congratulated for putting together an ingenious and original methodology with good potential for usefulness in applications.

Specific comments

There are areas where the phraseology can be improved to get the message across to the reader. These are listed section. Detailed technical corrections are in the next section.

page 1653

17 & 19. I have a problem visualizing set C3. C1 and C2 are fine, but C3 must equal C1, because $(a+b)/2 = b + (a-b)/2$. This calculation would apply linearly to each of the parameter values making up the vectors (points) theta1 and theta2. Figure 5 does not help, because topologically C3 is shown in the same region as C2, i.e. outside Btheta, the ‘first set of boundary points’. The puzzle is not unravelled by Table 6, which shows that the means of C1 & C3 are close but that the skews are very different. The point of the Sensitivity exercise is therefore lost on me. Please expand the explanation in the light of these comments.

page 1655

11 - 12: this text is misleading - surely the words ‘steps’ and ‘periods’ should be ‘it-

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erations' in the ROPE algorithm outlined above - this also applies to Figure 6, whose legend and caption should be rephrased.

Technical corrections

page 1642

4 a unique

5 of fitted hydrological

7 how is the quality of the input affected by the state (presumably catchment model) variables?

8 the word 'good' is used as often as 'robust' in the body of the paper

15a 'on Tukey's half-space depth'

15b instead of N, suggest 'set of a large number of randomly'

page 1643

11 remove ';'.

15 value

16 of parameter

21 since it – enable the classical

24 although

29 reorder these in the references: put :1 before :2 and re-label them there

page 1644

1 performance metric of

2 smoothen objective function surfaces

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4 different near-optimum

7 is the set defined by this list 'good'? somewhere this 'good' must be defined

14 identify

20 - 21a of the depth several fieldS.

21b used the concept of depth function

22-23 bad English - rephrase.

24 The only hydrological application

25 Chebana and Ouarda (2008) refers to a 'Working Paper' - what is it and where is it to be found?

page 1645

14 Alps?

17 238 to 1010 m a.s.l. ?

page 1646

10 - 11 the highlighted terms are not defined in the text

Also it is not clear which of the variables/parameters make up the set of 9 used in the sensitivity analysis and why these were chosen

page 1648

17 presumably 'observed discharge and temperature.' Are these daily values?

18 it would be helpful if this sentence was rephrased to emphasize that the errors are mutiplicative and therefore proportional to the flow

26 of the flow measurement error on model

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28 than

page 1649

2 what is this supposed to mean? Q_e is the true discharge not a parameter vector

3 omit 'an'

12 it would help to note $M=20$ in the figure 2 caption

18 - 20 especially as in Table 2 $M = 100$, which should be mentioned here

23 The meaning behind this sentence is not clear and it should be rewritten

page 1650 8 is the unit hydrograph defined by 2 parameters? if yes, please say so

9 - 11 suggest: 'By contrast, in this paper, models with many more than two parameters are considered. It is difficult to visualise the subset of best parameters in higher dimensions; instead, methods of computational geometry are used herein.'

page 1651

9 Figure 3 is very helpful as are the others

13 greatest depth. The closed polygon made by joining the points of depth 5 forms a convex hull, within which all points are deeper than 5.

16 please list these parameters somewhere with the ranges they take on in the sampling procedure, together with the deepest points (or the 10% deepest) if available

18 parameter vectors

19 set of objective function values is

20 deepest 10%

22 Fig 4 shows depths of 1 and >1 . What is L here? is it a mistake? Where does the deepest 10% of the previous sentence fit in to this discussion? I'm a bit lost as to what

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is intended in this paragraph.

page 1652

15 each of the 10 000 generated parameter vectors,

19 greatest depth

19 -(50 and 150 sets) in each of three time periods. Wich intersection sets consisted of 36 and 84 points? Did all of the 3 sets of size 50 have an intersection of 36 and all 3 time periods with 150 points in each set have an intersection of 84? A Venn diagram would be helpful.

23a points was considered, independence

23b - 24 led to a high probability of no

26 here, as elsewhere, please use the adjective 'great' instead of 'high' when referring to 'depth'

27 another

page 1653

4a close parenthesis at end of sentence?

4b - 6 it is not clear what 'due to their position' means in this context. please rewrite.

page 1654

2 C1 surely?

12 compromise

page 1655

2 a comma after Ym would help the meaning

4 'the set Ym is relabelled Xn'

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5 'does not differ by more'

10 iterations

page 1656

21 particular?

page 1660

Slope page 1661

discharge data sequences?

page 1662

temperature data sequences?

page 1671

The legend and the caption don't agree. Do you intend the legend to list the iteration number in the ROPE algorithm? If so then the caption should read 'model as a function of iteration of the ROPE algorithm.' and this should be matched by the text.

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