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Hydrology and Earth System Sciences Discussions

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

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We are very grateful for the thorough and constructive review of the paper. We are enclosing our statements to the comments of the anonymous reviewer:

Comment 1

Loosely speaking we call a set of points (reflecting the model parameter vector) in a high dimensional space well structured if it is connected (i.e. there is a continuous path connecting them). In our case we looked at convexity (if p_1 and p_2 are in the set then for each $0 < a < 1$ $p3 = ap_1 + (1-a)p_2$ also belongs to the set) which implies connectivity. The advantage of finding a convex set of good parameter vectors is that once the set is identified we do not have to run the model for more sets, instead it is enough to check if it is in the convex hull of the previously found set. Interactions between the parameters were not explicitly investigated, but they might influence the shape of the set.

Comments 2

High sensitivity parameters are desired as they help to calibrate the models. In our case we are not looking at individual parameters but at whole parameter vectors. We would like to find robust domains of parameters ; this means such parameter vectors where the change of any one of the parameters does not lead to a dramatic decrease of performance. A high sensitivity in our sense would mean that small errors (for example number of decimal digits considered) would lead to unexpected consequences.

Comments 3

In eq. 1 and 2 MELT is the amount of snow melt, DD is degree day factor, T is the mean daily air temperature, Tcrit is threshold temperature, DDo is degree day factor when there is no rainfall, k is a positive number, and P is daily precipitation. These corrections will be included in the revised version of the paper.

Comment 4

SM is actual soil moisture; PWP is limiting soil moisture at which potential ET take place.

Comment 5

There are 15 parameters to describe the model, out of which 9 parameters are used for this study.

Comment 6

Erratic objective function means that the objective function surface is **bumpy** having several local minima and maxima.

Comment 7

The distribution of discharge error is considered as normal, but assumed to be propor-

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tional to the observed discharge itself. This is similar to the assumption of a lognormal error. In fact our assumption on discharge error (5 %) is very optimistic. In reality the discharge error (relative) is much larger for extreme (very low and for very high) values. In these cases the error might easily exceed 50 %. As the consideration of the error was mainly used to illustrate the change of optimal parameter vectors, we think that a more realistic error (including autocorrelation) would have lead to even more different parameters.

Comment 8

Simulated annealing was use as optimization algorithm

Comment 9

The following table contains the parameter ranges used for the initial Monte Carlo simulation and for the set obtained at step 4 of the algorithm for subcathment Süssen (Fils).

Table: 1 Model parameter ranges

Parameter	Description	Step1		Step4	
		Min	Max	Min	Max
T_{crit}	Threshold for snow melt initiation	-0.1	1.9	0.7	1.2
DD	Degree-day factor	1.1	3.1	2.2	3.1
Dew	Precipitation/Degree-day relation	0.3	2.5	0.4	1.6
β	Model parameter (shape coefficient)	0.3	2.3	1.4	1.8
L	Threshold water level for near surface flow	11.0	13.0	11.0	12.9
K_0	Near surface flow storage constant	5.9	7.9	6.2	7.7
K_1	Interflow storage constant	11.4	14.0	11.4	13.2
K_{per}	Percolation storage constant	153.3	155.3	153.4	155.3
K_2	Baseflow storage constant	21.2	23.2	22.6	23.2

As one can see that only some of the ranges decreased from step 1 to step 4.

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Comment 10

The parameters which considered for this study are given in the table 1

Comment 11

The reasonable limits of all nine parameters are given in table 1.

Comment 12

Discontinuity of the objective function is in principle no problem for the suggested methodology. We experienced irregularities of the surface of the objective function (erratic surface comment 6) mainly because of threshold type formulation of certain processes. As we are not intending to find a single global optimum but look for a (geometrically defined) set of good parameters a possible discontinuity is not an obstacle.

Comment 13

The following table shows the mean discharge for the 3 selected time periods. The whole period is more or less homogeneous thus the transferability of the parameters is not surprising. However note that our goal was to compare the transferability of the parameter vectors with different geometrical position with respect to the set of good parameters. As one can see from table 5 (in the paper) that parameter vectors from the boundary and the inside of the good set which perform equally well for the calibration period behave differently for the validation periods. In fact the inside point lead to significantly better performance than the boundary points.

Table: 2 Runoff characteristics for different time periods

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	Rottweil (Neckar)		Tübingen (Steinlach)		Süssen (Fils)	
Time period	Annual Precipitation (mm)	Annual Discharge (mm)	Annual Precipitation (mm)	Annual Discharge (mm)	Annual Precipitation (mm)	Annual Discharge (mm)
1961-1970	997.53	375.26	851.84	400.36	1007.94	575.55
1971-1980	908.48	309.36	808.14	366.62	960.02	512.62
1981-1990	997.21	385.66	888.84	404.86	1041.72	541.81

Comment 14

At the present moment the suggested algorithm can only be used for gauged catchments. For ungauged catchments we hope that a relationship between catchment properties and the geometrical properties of the good sets can be found. However this task requires a lot more research.

Comment 15

The table will be extended in the revised version. Enclosed please find it.

Comment 16

The modified figure will be included.

Thanks for the list of typos we'll correct them.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 5, 1641, 2008.