Selection of the appropriate variables for regionalisation in mesoscale basins

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Introduction

The regionalisation of hydrological model parameters on the basis of catchment characteristics is plausible. However, model parameter estimation and subsequent fitting of regional transfer functions is often not appropriate due to non-uniqueness of the calibrated hydrological model parameters.

The multi-scale parametrisation technique (MPR) was proposed (Samaniego et al., 2010a) to address this problem, which requires only the estimation of a few transfer function parameters. MPR not only takes into account the subgrid variability of the model parameters but also allows to make robust predictions at an interior location of a donor basin. Predictions in an ungauged basin, however, may require the selection of suitable donor basins. This is commonly done with nearest neighbour approaches (Samaniego et al., 2010b) or other statistical techniques called stepwise methods. Here, we used the recently proposed SAV algorithm by Bardossy and Singh (2010). This robust algorithm is based on the depth function approach which helps to finds predictors as a convex combination of catchment characteristics. i.e., to restrict the regionalisation to an ungauged catchments whose relevant properties for the regionalisation are in between the properties of the donor catchments in a geometrical sense.

To illustrate the application of these techniques, 22 southern German basins ranging from 70 to 4,200 km² were selected. For each basin a number of catchment descriptors were quantified, e.g., mean slope, aspect, shape factor, mean elevation, and several climatic indices such as, the antecedent precipitation index and mean monthly temperature. Daily stream flow time series correspond to the period from 1961 to 2000, along with a large set of parameters calibrated for the mHM model will be used for validation of results.

Results indicate that SAV algorithm is very useful for finding adequate transfer parameters from donor basins for prediction in an ungauged catchments. These parameters were found by identifying a convex combination of catchment characteristics.

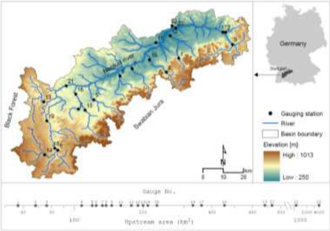


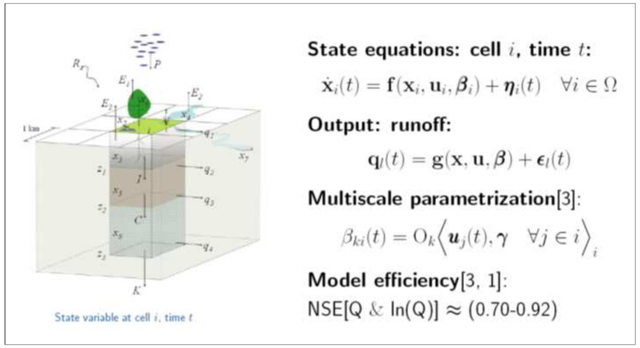
Figure 1: Study area (Kumar et . al. 2010)

Study area description

Site name: Upper Neckar, Germany
Catchment area: 58 – 4000 km²
Elevation: 250-1015 m amsl
Annual mean precipitation: 900 m

Model Used

Name: Mesoscale hydrologic model (mHM)
Optimisation: Simulated annealing
Free Parameter Opt.: 46



State equations: cell i, time t:

$$\dot{\mathbf{x}}_i(t) = \mathbf{f}(\mathbf{x}_i, \mathbf{u}_i, \boldsymbol{\beta}_i) + \boldsymbol{\eta}_i(t) \quad \forall i \in \Omega$$

Output: runoff:

$$\mathbf{q}_l(t) = \mathbf{g}(\mathbf{x}, \mathbf{u}, \boldsymbol{\beta}) + \boldsymbol{\epsilon}_l(t)$$

Multiscale parametrization[3]:

$$\beta_{ki}(t) = \mathrm{O}_k \left\langle \boldsymbol{u}_j(t), \boldsymbol{\gamma} \quad \forall j \in i \right\rangle_i$$

Model efficiency[3, 1]:
NSE[Q & ln(Q)] ≈ (0.70-0.92)

Figure 2: Schematic representation of the mHM model (Samaneigo et. al. 2010) .

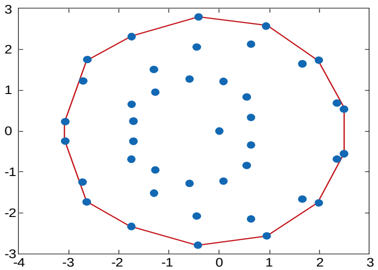


Figure 3: Convex hull.

Depth function

Data depth is a quantitative measurement of how central a point is with respect to a data set or a distribution. This gives us the central outward ordering of multivariate data points.

$$D_X(p) = \min_{nh} \left(\min \left(|\{x \in X (nh, x-p) > 0\}| \right), \left(|\{x \in X (nh, x-p) < 0\}| \right) \right)$$

Selection of Appropriate Variable

(SAV) Algorithm (Bardossy and Singh 2010) Stepwise selection of reasonable catchment properties:

1. Select catchment property.
2. Find convex hull.
3. Divide catchments inside and outside.
4. Check intersection of parameters for inside catchments.
5. If no intersection between the sets add discriminating catchment property and continue with step 2.

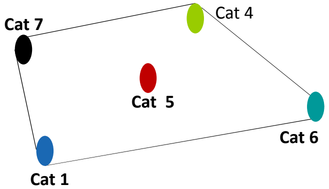


Figure 4: Example for gauged and an ungauged catchment and convex hull formation.

Inside Catchments	Boundary Catchments
5	1
10	2
15	3
16	4
17	6
18	7
19	8
20	9
21	11
	12
	13
	14
	22

Table 1: Ungauged and gauged catchments.

Inside catchments	Total number of possible combinations (4 catchments combinations)
5	216
10	125
15	268
16	245
17	92
18	14
19	14
20	122
21	18

Table 2: Number of possible combinations for four boundary catchments which includes the properties of the given inside catchments.

Inside catchment	Boundary catchments	Weight	Area	Mean slope	Drainage density
	1	0.038689	58.8000	8.9820	2.1820
	4	0.368304	108.3000	9.6300	1.9690
	6	0.420767	124.9000	5.9710	2.2460
	7	0.172239	161.3100	8.4320	2.3650
5			122.5000	7.8590	2.1620

Table 3: A set of possible boundary catchments for catchment 5 and corresponding weights.

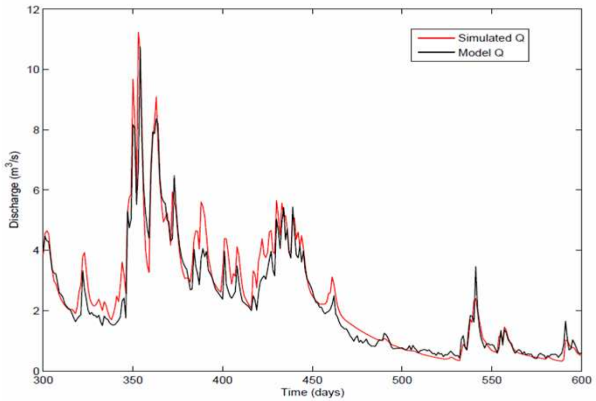


Figure 5: Hydrograph for catchment 5.

Conclusions

- The SAV algorithm is very useful for finding adequate transfer parameters from donor basins for prediction in an ungauged catchments.
- The idea of convex combination could be used to check whether a set of properties should be used for regionalisation.

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