Assessing the accuracy of simulated peak discharges using Self-Organizing Maps

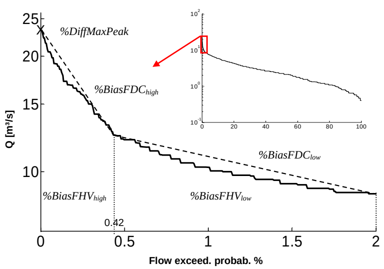
Markus Casper[1], Marcus Herbst[1]

Background

We use Indices specifically conceptualized to extract information on the peak discharge characteristics of model output time series which are obtained from Monte-Carlo simulations with the distributed watershed models NASIM, LARSIM and WaSIM-ETH. The test watershed is the 129 km² low-mountain range catchment "Schwarze Pockau" in Saxony (Germany)

Approach

- Data: Monte-Carlo simulation with three rainfall-runoff models on the randomly sampled parameter space (N=4000 runs)
- Five index measures (derived from the flow duration curve) are calculated for each model run

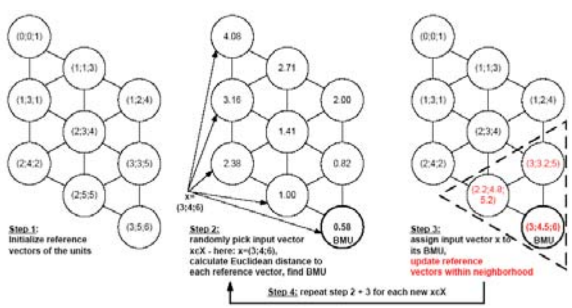


Derivation of index measures from the upper 2% section of the flow duration curve (FDC).

- A Self-Organizing Map (SOM), consisting of nodes $i=1\dots k$ which are characterized by an index vector

$$\mathbf{m}_i = [\mu_{i1}, \mu_{i2}, \dots, \mu_{in}]^T \in \Re^n$$

with the same dimensionality as the output time series $\mathbf{x} \in X$ is trained:

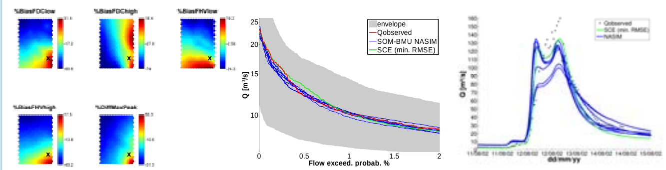


BMU: $\|\mathbf{y} - \mathbf{m}_{c(y)}\| = \min_i \{\|\mathbf{y} - \mathbf{m}_i\|\}$

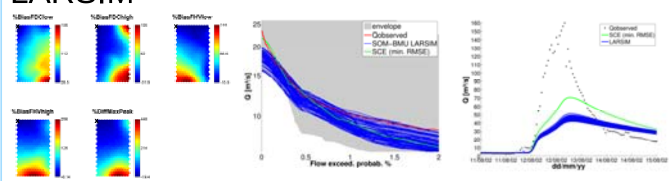
Results

The characteristics of the observed time series are represented with partially superior accuracy than the reference simulation obtained by implementing a simple calibration strategy using the global optimization algorithm SCE-UA.

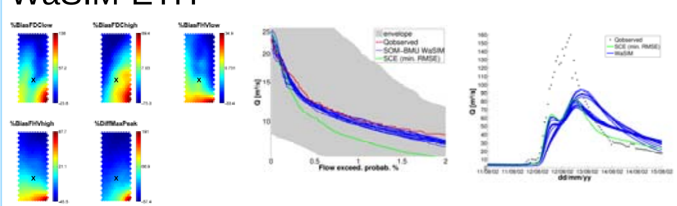
NASIM



LARSIM



WaSIM-ETH

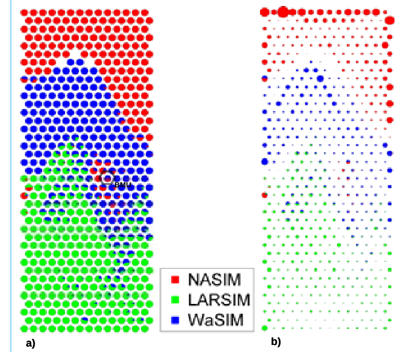


Left figure:
Distribution of reference vector (i.e. indices) properties on the map. The position of the BMU is marked.

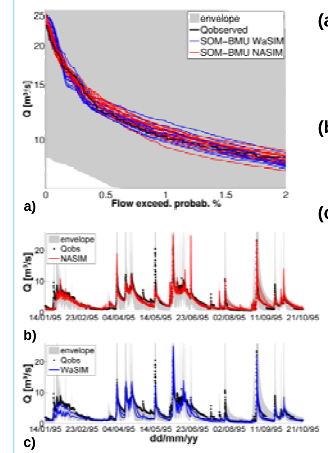
Central figure:
Flow duration curves (upper 2% section): Simulations corresponding to the BMU compared to the observed discharge and the results of an optimization approach using SCE-UA.

Right figure:
Results for the validation event August 2002 (BMU realizations and SCE-UA, RMSE).

Model intercomparison



Intercomaparison of NASIM, LARSIM and WaSIM:
(a) The neurons of the SOM are reproduced as pie charts that represent the percentage of data from each model that has been attributed to the neurons via the training.
(b) same as (a) but displayed as a "hit histogram", i.e. the size of the pie charts is proportional to the number of data items attributed to the corresponding neuron.



(a) Flow duration curves (upper 2% section): Simulations corresponding to the BMU of the SOM trained on the combined model data compared to the observed discharge and the results of an optimization using SCE-UA.
(b) Time series of the model NASIM corresponding to the BMU of the SOM trained on the combined model data compared to the observed discharge.
(c) Time series of the model WaSiM-ETH corresponding to the BMU of the SOM trained on the combined model data compared to the observed discharge.

The most prominent advantage of using SOM in the context of model analysis is that it allows comparatively evaluating the data from two or more models. Our results highlight the individuality of the model realizations in terms of the index measures and shed a critical light on the use of conventional calibration strategies.

References:

Herbst, M., Casper M.C.: Towards model evaluation and identification using Self-Organizing Maps. Hydrol. Earth Syst. Sci., 12, 657-667, 2008.

Herbst, M., Gupta, H.V., Casper, M.C. (2009): Mapping model behaviour using Signature Indices and Self-Organizing Maps, Hydrology and Earth System Sciences, **13**:395–409

Herbst, M., Casper, M.C., Grundmann, J., Buchholz, O. (2009): Mapping of model behaviour for flood prediction purposes, Natural Hazards and Earth System Sciences, 9: 373-392

This work was carried out using the SOM-Toolbox for Matlab by the "SOM Toolbox Team", Helsinki University of Technology (http://www.cis.hut.fi/projects/somtoolbox)

[1]Physical Geography, University of Trier, 54286 Trier, Germany
e-mail: casper@uni-trier.de, Tel.: +49 651 2014518, Fax: +49 651 2013976

Financial support for this research provided by the German Federal Ministry of Education and Research (BMBF, grant 0330699D) is gratefully acknowledged.

Universität Trier