Very good prediction of a distributed rainfall runoff model but for all wrong reasons

**Introduction:**
Addressing several issues like sedimentation, water quality, conservation measures, environmental and geomorphologic studies etc, needs the prediction of erosion patterns which, in turn, needs runoff source areas within the catchment. Several modeling alternatives exist, all with certain potential and limitations. The use of a distributed rainfall-runoff model is basis for identification of such areas. Such model, even in case of physically-based, needs prior calibration of some or many parameters. The optimization and prediction capability of those distributed models is being assessed based on their ability to correctly predict lumped hydograph at watershed outlet.

The presented work aims to show the unreasonable consequences that we have encountered while calibrating and applying a distributed rainfall runoff model. The model used was WaSiM-ETH, a physically-based spatially distributed rainfall-runoff model. At first to apply for events in a small agricultural catchment in central Belgium, its 11 parameters were calibrated using Gauss-Marquardt-Levenberg algorithm. As is the trend, the calibration was done with objective function of minimizing prediction errors in the catchment outlet. Very nice results were obtained with closely matching hydrographs and Nash-Sutcliffe efficiency as high as 0.97 in calibration and 0.81 in validation. But when the modeled runoff source areas within the catchment were investigated, a very much unrealistic patterns were observed with almost all the runoff are coming from a small isolated patch in the catchment. Further we calibrated the model using more accepted Schuffle Complex Evolution (SCE-UA) algorithm and, in addition, sets of equally well performing parameter vector are estimated based on Tukey’s half space function depth. They are applied to a bigger Rems catchment in southern Germany where also we found that very good model performance were not accompanied by the reasonable runoff patterns within the catchment.

**Study Area**

<table>
<thead>
<tr>
<th>Catchment</th>
<th>Central Belgium</th>
<th>Southern Germany</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>111 ha</td>
<td>580 sq. km</td>
</tr>
<tr>
<td>Mean annual precipitation</td>
<td>740 mm</td>
<td>900 mm</td>
</tr>
<tr>
<td>LU</td>
<td>farmland; scarce built-up areas</td>
<td>agriculture; forest; built-up areas</td>
</tr>
<tr>
<td>Soil</td>
<td>loess (Haplic Luvisols)</td>
<td>light sandy on highs; loamy clay on lows</td>
</tr>
</tbody>
</table>

**Model used:** Water balance & flow Simulation Model [WaSiM-ETH]

**Parameters estimation:**
- Gauss-Marquardt-Levenberg method [PEST package]
- Schuffle complex evolution algorithm [SCE-UA]
- Use of statistical depth function [Tukey’s Half space depth]

**Some Results:**

The model is calibrated for an event in Ganspoel catchment and very well matching of hydrograph is obtained. But the spatial runoff within the catchment producing this hydrograph is completely unrealistic.

The model is calibrated for each subcatchment individually in Rems catchment and reasonably matching hydrographs are obtained. But the runoff patterns within the catchment is again unacceptable as they vary highly among subcatchments.

**Conclusions:**
- Well performing parameter sets may lead to good results with high model efficiency but these can be for all the wrong reasons
- Better hydrographs prediction by models do not guarantee better hydrology representation by them.

**References**