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Reliability of distributed results from the spatially distributed hydrological modeling

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The increasing accessibility of computing means has made the application of spatially-distributed hydrological model an attractive perspective for both researchers and practitioner hydrologists. Distributed models should be able to explicitly represent the spatial variability of some, if not most, of the important land surface and climatic characteristics. Such models have important applications, for eg., to estimate spatially distributed surface runoff that enable further to calculate spatially distributed soil erosion. But, 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 generally assessed based on their ability to correctly predict lumped hydrograph 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 the selected events in a small agricultural catchment in central Belgium, its 11 parameters were calibrated using Gauss-Marcquardt-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, in addition, and applied to a bigger Rems catchment in southern Germany where also we found that the very good model performance were not accompanied by the reasonable runoff patterns within the catchment.

A new concept, based on the statistical depth function- Tukey's Half-space depth, has been investigated further, which yields not a single best parameter set but several sets of good parameter which are deep. The model performs quite well and equally efficient with the chosen deep 21 different parameter sets and the runoff patterns within the catchment is also reasonable. But the surface runoff from the different good parameter sets, when separated by using a digital filter, are found to vary highly, as much as four times, thus giving unacceptably different results when they are used further, for eg. in estimating soil erosion by the surface runoff. The high values of spatial correlation and the rank correlation among the surface runoff from different good parameter sets prove that the patterns are uniform and reasonable but high variation in the amount raise the question mark in their reliability.

These results, thus, show the very good predictions by the rainfall runoff model but for all wrong reasons. This indicates that simply the better hydrograph prediction by a physically-based distributed rainfall runoff model does not guarantee better hydrology representation by it thus making its distributed results in doubt to be accepted.