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Reply on RC1

Francesco Fatone et al.

Author comment on "Advanced sensitivity analysis of the impact of the temporal distribution and intensity of rainfall on hydrograph parameters in urban catchments" by Francesco Fatone et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2021-99-AC1, 2021

Manuscript: HESS-2021-99

General notes:

The manuscript: "Advanced sensitivity analysis of the impact of the temporal distribution and intensity in a rainfall event on hydrograph parameters in urban catchments: a case study" proposed by Fatone et al., introduces a sensitivity coefficient to study the impact of the variability of hydrodynamic model parameters depending on rainfall distribution and intensity. Results, determined for a SWMM model of an urban catchment in Kielce (Poland), show the influence of rainfall distribution and intensity on the sensitivity factors

Although the paper is quite interesting and it has the potential to be published in HESS, it needs some minor adjustments.

Review 1

In particular, the novelty and innovative aspects of the work could be better highlighted in the abstract and introduction.

Comment 1

Thank you for your valuable comment. The abstract has been corrected to read: Knowledge of the variability of the hydrograph of outflow from urban catchments is highly important for measurements and evaluation of the operation of sewer networks. Currently, hydrodynamic models are most frequently used for hydrograph modeling. Since a large number of their parameters have to be identified, there may be problems at the calibration stage. Hence, the sensitivity analysis is used to limit the number of parameters. However, the current sensitivity analysis methods ignore the effect of the temporal distribution and intensity of precipitation in a rainfall event on the catchment outflow hydrograph. The article presents the methodology of construction of a simulator of catchment outflow hydrograph parameters (volume, maximum flow). For this purpose, uncertainty analysis results obtained with the use of the GLUE (Generalized Likelihood Uncertainty Estimation) method were used.

A novel sensitivity analysis of catchment hydrodynamic models was also developed, which

may find application in the analysis of the performance of sewer networks and underground infrastructure facilities. Using the logistic regression method, an innovative sensitivity coefficient was proposed to study the influence of variability of hydrodynamic model parameters depending on the temporal rainfall distribution, rainfall genesis (in the Chomicz scale) and uncertainty of the estimated simulator coefficients on the outflow hydrogram parameters. The developed model makes it possible to analyze the influence of identified parameters of the Storm Water Management Model (SWMM) on the outflow hydrogram taking into account local rainfall conditions, which has not been analyzed so far. Compared to the currently developed methods, the influence of uncertainty of identified coefficients in the logistic regression model on the results of sensitivity coefficient calculations was included in the analyses. So far, this aspect has not been taken into account in the methods of sensitivity analysis despite the fact that in this approach the reliability of simulation results is analyzed. The results indicated a considerable influence of rainfall distribution and intensity on the sensitivity factors. The greater the intensity and of rainfall, the lower the impact of the identified hydrodynamic model parameters on the hydrograph parameters. Additionally, the calculations confirmed the significant impact of the uncertainty of the estimated coefficient in the simulator on the sensitivity coefficients. The results obtained in the context of sensitivity analysis have a significant effect on the interpretation of the relationships obtained. The approach presented in the study can be widely applied at the model calibration step and for the appropriate selection of hydrographs for identification and validation of model parameters. The results of calculations obtained in the study indicate the advisability of including the rainfall genesis in the sensitivity analysis and calibration of hydrodynamic models, which results from different sensitivity of models for normal, heavy, and torrential rainfall types. In this context, it is necessary to first separate the rainfall data by genesis, for which the analyses, including the sensitivity analysis, and calibration will be performed. Bearing in mind the obtained results of calculations at the step of identification of hydrodynamic model parameters and their validation, it is necessary to take into account the rainfall conditions, as much smaller values of sensitivity coefficients have been found for the rainfall caused by heavy rainfall than for torrential rainfall. Considering the obtained values of sensitivity coefficients, model calibration should not include only the episodes of high rainfall intensity, which may lead to calculation errors at the step of model application in practical considerations (assessment of sewer network operation conditions, design of reservoirs, flow control devices, green infrastructure, etc.).

Also within introduction novelity and innovatine aspect of the work was highlighted. (line 124 – 127 and 150 – 156)

Review 2

Moreover, only the temporal rainfall variability is evaluated, without considering the strong connection with the spatial rainfall distribution, especially in a small urban environment (see Schilling, 1991, Berne et al., 2004; Ochoa-Rodriguez et al., 2015, Cristiano et al. 2017). This aspect should be at least discussed in the conclusions.

Comment 2

Thank you for your valuable comment. Indeed, the spatial distribution of rainfall has a strong influence on the parameters of the outflow hydrogram. In small urban catchments, the spatial distribution of rainfall has a negligible effect on the hydrogram, so it was not included in the present analyses. The spatial distribution of rainfall in the catchment is referred to in the introduction and summary.

Review 3

The methodology needs to be restructured. Elements like SWMM and the GLUE are described only at the end of the methodology section, while they should be moved to the introduction or in an additional section "Theoretical background" before the study case description.

Comment 3

Thank you for your valuable comment. As requested by the reviewer, the introduction refers to the introductory data regarding the GLUE method.

"To understand the modeled processes in urban catchments and to determine the influence of the interactions between identified parameters on simulation results, uncertainty analysis (GLUE - Generalized Likelihood Uncertainty Estimation) is performed. This method is widely used in the analysis of stormwater quantity and quality for models of urban catchments, agricultural catchments (Dotto et al. 2012, Mirzaei et al. 2015), storage reservoirs (Kiczko et al. 2018), wastewater spillage (Fraga et al. 2016), etc., which is confirmed by a large number of studies in this field. In this approach, the empirical distributions of parameters identified in hydrodynamic models (e.g., catchment retention, roughness coefficients of impervious and pervious areas, channels, etc.) as well as a confidence interval (e.g., 95%) are determined, including the data obtained from measurement results".

"Despite the limitations of the local sensitivity analysis method and the complex implementation of global sensitivity analysis, in both cases, the aspects related to local rainfall conditions are considered to a limited extent. Recent studies of urban catchments indicate that the temporal and spatial distributions of rainfall are very important factors that strongly influence the catchment response (Schilling, 1991, Berne et al., 2004; Ochoa-Rodriguez et al., 2015, Cristiano et al. 2017). However, a number of issues have not been fully clarified. The current methods ignore the influence of rainfall genesis on the results of sensitivity analysis. It is not clear how the model sensitivity (maximum flow, hydrogram volume) changes for rainfall events resulting from high (convective) or low (low) intensity rainfall. The LSA and GSA methods ignore the influence of the temporal distribution of rainfall on the sensitivity coefficients, which is contrary to the literature (Schilling 1991) performed for various urban catchments. This is important, from the point of view of selecting catchment outflow hydrograms for parameter identification and validation in the context of rainfall conditions (rainfall genesis, rainfall intensity, temporal distribution). It is also of great methodological importance in the context of modifying the currently used methods for sensitivity analysis of catchment hydrodynamic models. In the methods of sensitivity analysis based on statistical models, the influence of uncertainty of estimated coefficients on sensitivity coefficients is neglected. From the point of view of reliability of the obtained analysis results, it is important when deciding on the choice of the method of parameter identification in hydrodynamic models (GIS, maps, etc.) in order to reduce the uncertainty of simulation results''

Review 4

The sections Methodology and Results would benefit from a short intro describing the structure of the section, to guide the reader.

Comment 4

Thank you for your valuable comment. The methodology includes a description that discusses the subdivision of the manuscript. "Due to the extensive nature of the analyses carried out, the manuscript has been divided into several sections covering: characteristics of the object of study; methodology, which presents an innovative algorithm for the construction of a logistic regression model and subsequent computational steps, i.e. determination of the hydrodynamic model of the catchment, identification of the threshold values of hydrogram parameters of catchment outflow by means of the hydrodynamic model, uncertainty analysis by means of the GLUE method, development of the logit model and verification, analysis of the influence of rainfall genesis and temporal distribution of rainfall on the calculated sensitivity coefficients, and assessment of the influence of uncertainty of identified coefficients in the logit model on the values of sensitivity coefficients".

"The developed methodology for sensitivity analysis of hydrodynamic models includes several independent steps, which include: preparation of data for model development and model performance, conducting uncertainty analysis by GLUE method, development of a logit model for certain threshold values of hydrogram parameters and model verification, calculation of sensitivity coefficients considering rainfall genesis, temporal distribution of rainfall, evaluation of the effect of uncertainty of the identified coefficients in the logit model has the results of sensitivity analysis".

Review 5

The manuscript is overall clear; however, it would benefit from a native speaker revision to improve the English quality.

Comment 5

Thank you for your comment. The manuscript has been proofread by a specialized language proofrading service (AJE).

Review 6

Title: I'd suggest rephrasing and shortening it. Otherwise, at consider adding "…the temporal distribution and intensity OF PRECIPITATION in a…." and removing ": a case study".

Comment 6

Thank you for your valuable comment. The article title has been modified.

Review 7

Abstract: The aim and the novelty of the work could be better highlighted in the abstract. Please avoid unnecessary abbreviations in the abstract.

Comment 7

The abstract has been modified.

Review 8

[2,3] “there is the need to model the runoff generation”

[2, 52] “As shown in the literature (…), the analysis…”

Comment 8

Thank you for your comments. Language corrections were made in the manuscript.

Review 9

[Introduction] consider to add a short paragraph that describes the structure of the paper with the aim to better guide the reader.

Comment 9

Thank you for your valuable comment. In the introduction, a brief paragraph was included to describe the layout and content of the manuscript. “Due to the extensive nature of the analyses carried out, the manuscript has been divided into several sections including: characteristics of the study object; methodology, which presents the innovative algorithm for the development of the logistic regression model and subsequent computational steps i.e. determination of a hydrodynamic model of the catchment, identification of the threshold values of hydrogram parameters of outflow from the catchment by means of the hydrodynamic model, uncertainty analysis by the GLUE method, development of a logit model and verification, analysis of the influence of rainfall genesis and temporal distribution of rainfall on the calculated sensitivity coefficients, assessment of the influence of uncertainty of the identified coefficients in the logit model on the values of sensitivity coefficients”.

Review 10

[5, Methodology]: please check the section numbers

Comment 10

Thank you for your comment. The numbers of the sections have been corrected.

Review 11

[5,137]: Please add a reference and motivation for this choice. Why 4 h has been chosen as threshold for independent events?

Comment 11

Thank you for your comment. The literature on the identification of independent rainfall events in rainfall time series has been completed (Dunkerley 2008; Joo et al. 2014).

Joo, J., Lee, J., Kim, J.H., Jun, H., Jo. D.: Inter-Event Time Definition Setting Procedure for Urban Drainage Systems, WATER, 6, 45 – 58, https://doi.org/10.3390/w6010045,

2014.

Review 12

[5, 42] Info regarding the length of the dry period is already mentioned in section 2. Please restructure this part and put all the data regarding the study case in Section 2, and leave only the methodology description in Section 4.

Comment 12

The data for independent rainfall events and the dry period were separated, i.e., methodology and results.

Review 13

[6, 164] No need to repeat Storm Water Management Model

Comment 13

The comment was introduced in the manuscript.

Review 14

[7, 165] Sentence not clear. Please rephrased it.

Comment 14

The suggestion was introduced in the manuscript.

Review 15

[7, 171] GLM is defined only in page 9, line 214. Please add here the extended name.

Comment 15

Thank you for your comment. GLM - Generalized Likelihood Model

Review 16

[8, 172] The GLUE is well described only in Section 4.5. Here it is mentioned as abbreviation without description before. Please fix this issue and refer to section 4.5 and to some references for a description.

Comment 16

Thank you for your comment. In the current version of the manuscript, the GLUE method

is described in the introduction (line 74 – 80) and the sections where the methodology is described (Section 3.6).

Review 17

[17, 387-389] I assumed these lines are related to the table? In case, please include them in the caption (and rephrase them).

Comment 17

Thank you for your valuable comment. It has been implemented in the manuscript.

Review 18

[Methodology, 5.4] please avoid brackets in the titles of the subsections.

Comment 18

Thank you for your valuable comment. It has been implemented in the manuscript.

Review 19

[23, 516] representS

Comment 19

Thank you for your valuable comment. It has been implemented in the manuscript.

Review 20

[23, 516-517] why? Please justify this sentence

Comment 20

The original sentence was: "It is necessary to search for methods that will yield reliable results reflecting the reality as well as possible on the one hand." to make it clear we rephrased it:

"It is necessary to search for the methods that will yield reliable results reflecting the reality as well as preserve the physical interpretation of its equations and parameters".

Review 21

[Conclusions] Please add in the first paragraph of this section the motivation and the questions that this study aimed to answer, and include a discussion about the possible limitations, impacts and possible improvements.

Comment 21

Thank you for your comment. The following paragraph was added in Conclusions: "The computational methodology proposed in the manuscript is universal and can be applied to any urban catchment. The simulation results presented in this paper refer to a single catchment. Therefore, further analyses are advisable to verify the model for the catchments with different physical and geographical characteristics. Thus, it is advisable to determine the scope of applicability of the developed computational model. Considering the usefulness of the obtained relations and the great influence of rainfall genesis and temporal distribution of rainfall on the sensitivity coefficients, further studies are necessary. The purpose of these analyses is to extend the developed methodology of sensitivity analysis to additionally take into account the shape, area of the catchment, type of development, path of the sewer network, retention of the sewer network. The analysis of the effect of temporal distribution of rainfall, together with the spatial distribution, seems to be a particularly interesting issue, especially that both distributions strongly depend on the rainfall genesis. However, the design of an appropriate experiment seems challenging".

References:

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Ochoa-Rodriguez, S., Wang, L., Gires, A., Pina, R., Reinoso- Rondinel, R., Bruni, G., Ichiba, A., Gaitan, S., Cristiano, E., Assel, J., Kroll, S., Murlà-Tuyls, D., Tisserand, B., Schertzer, D., Tchiguirinskaia, I., Onof, C., Willems, P., and ten Veldhuis, A. E. J.: Impact of Spatial and Temporal Resolution of Rainfall Inputs on Urban Hydrodynamic Modelling Outputs: A Multi- Catchment Investigation, J. Hydrol., 531, 389–407, 2015.

Schilling, W.: Rainfall data for urban hydrology: What do we need?, Atmos. Res., 27, 5–21, 1991.