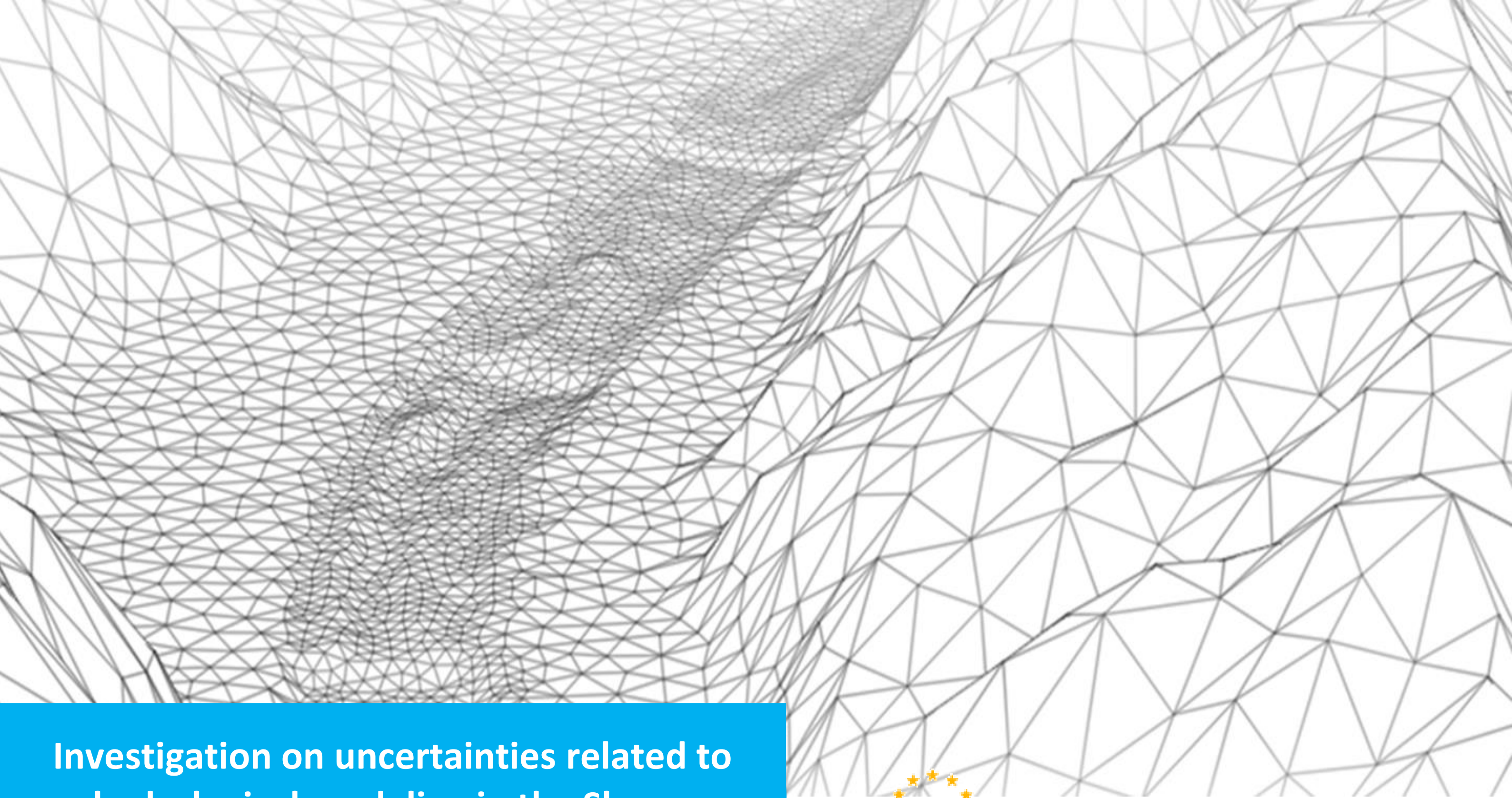

Investigation on uncertainties related to hydrological modeling in the Skawa catchment, Poland

HYDROEUROPE

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Case Skawa Catchment (Poland)

Paweł Gilewski, Warsaw University of Technology
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1. Introduction

1.1. Study area

The Upper Skawa catchment is a small mountainous catchment in southern Poland. It is predominantly covered by non-irrigated arable lands and coniferous and mixed forests. The catchment, having a total area of 240.4 km2, can be sub-divided into six sub-catchments (Figure 1).

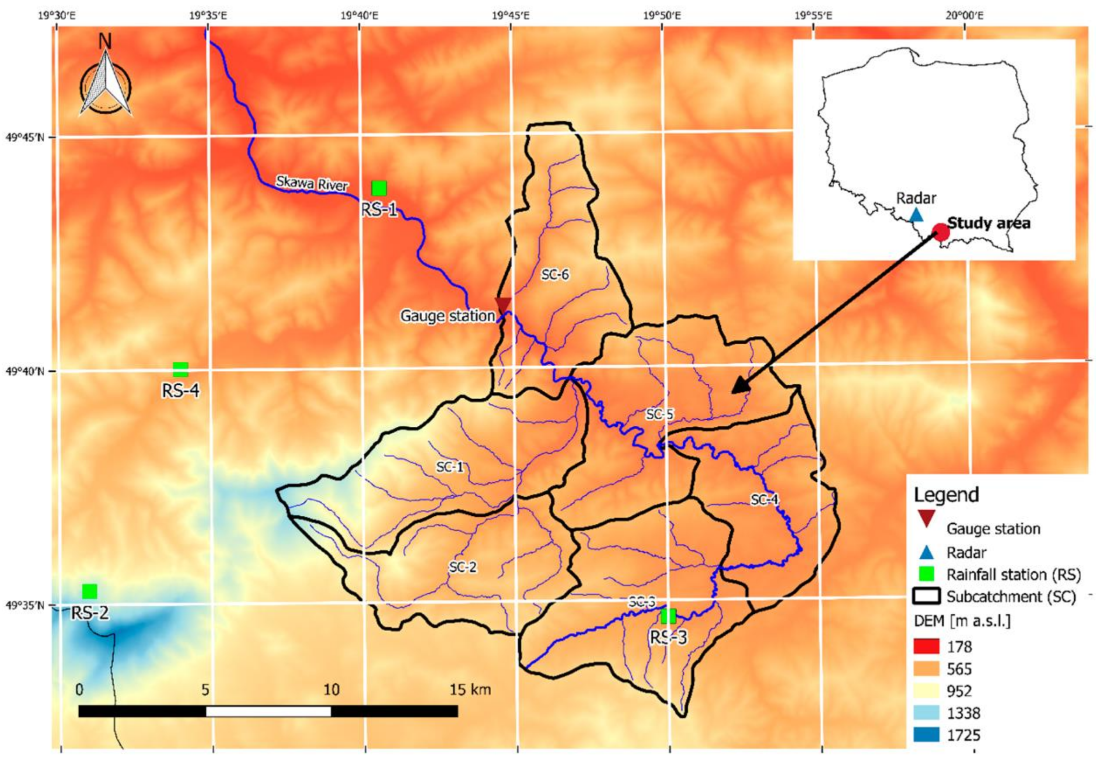

Figure 1. Location of the study area—the Upper Skawa River catchment, in reference to the digital elevation model (DEM) and the map of Poland.

The annual rainfall of the sub-catchments ranges from 700 mm to 1200 mm. Besides that, the annual mean temperature up to 700 m a.s.l. varies from 4 °C to 6 °C, between 700–1100 m a.s.l. from 4 °C to 6 °C, and below 4 °C above 1100 m a.s.l. In the catchment area, there are four rain gauges, and one among them is located directly on-site. The discharge data are available at the river gauging station in Osielec. The closest meteorological radar is located in Ramża around 100 km north-west of research area.

Historically, flash floods in this area were already noticed in the XV century. The most recent flood events occurred in 2010, 2014, and 2019, leading to substantial material losses in built-up parts of the catchment and significant changes to the topography in forested areas. The logs transported in the streams have a considerable impact on the accumulation of sediment transport, increasing the risk of flooding. Climate change impact will most likely result in even more frequent and intense precipitation events. Considering that, we can expect even more severe floods in the years to come.

The case study of the upper Skawa catchment, due to its characteristics (relatively small area, mountainous character, quick response time, and a limited number of rain gauges), is representative of similar study areas in Slovakia and the Czech Republic, as well as other parts of Europe.

1.2. Data and software

All data required to perform the hydrological simulation are provided for the user. In the following folders, you can find:

- Skawa_model - the initial version of the hydrological model
- GIS_data - the shapefiles with catchment and locations of meteo stations
- Precipitation_data - the Excel file with precipitation measurements from rain gauges, as well as a brief tutorial on AMC calculations

For the processing of GIS data, any GIS software is required. However, I encourage you to use QGIS as this is open-source software.

Rainfall-runoff hydrological simulations must be executed using the HEC-HMS model. You can use the most up-to-date version, but often it is better to use older versions (like 4.2.1) because they are more stable.

2. Setting up a model

2.1. Loading initial model

Load the initial version of the model, which is provided in the folder *Skawa_model*. Add the shapefile of the catchment to the view. Investigate and understand well the particular elements of the model.

2.2. Fill in the required data

Using any GIS software, calculate the area of individual sub-catchments (km^2) based on the provided shapefile representing the catchment. The results of calculations should then be divided by 1000000 to obtain results in km2. In that unit, you should fill in the values in the HEC-HMS model.

In the tab *Components* using the tables below, fill in the blanks for:

- *Loss Method → SCS Curve Number* (**Table 1**)
- *Transform Method → Snyder Unit Hydrograph* (**Table 2**)
- *Baseflow Method → Recession* (**Table 3**)

Table 1. Parameters for loss method

Sub-catchment	Curve Number [-]	Initial Abstraction [mm]	Impervious [%]
BYSTRZANKA_Z_CISNIAWA	41.18	27.21	2.2516
BYSTRZANKA_OD_ZRODLA	43.02	25.23	1.4947
SKAWA OD ZRODLA DO POZOGI	50.88	18.39	1.1063
SKAWAODPOZOGIDOMALEJOWKI	52.82	17.01	1.6057
OD_MALEJOWKI_DO_BYSTRZANKI	51.51	17.39	12.093
OD_BYSTRZANKI_DO_OSIELCA	51.73	17.77	2.0053

Table 2. Parameters for transform method

Sub-catchment	Lag time [h]	Peaking coefficient [-]
BYSTRZANKA_Z_CISNIAWA	5.04	0.4
BYSTRZANKA_OD_ZRODLA	3.79	0.4
SKAWA OD ZRODLA DO POZOGI	3.75	0.4
SKAWAODPOZOGIDOMALEJOWKI	4.39	0.4
OD_MALEJOWKI_DO_BYSTRZANKI	5.00	0.4
OD_BYSTRZANKI_DO_OSIELCA	2.91	0.4

Table 3. Parameters for baseflow method

Sub-catchment	Initial Discharge [m³/s]	Recession Constant [-]	Threshold Flow [m³/s]
BYSTRZANKA_Z_CISNIAWA	0.5	0.9	0.7
BYSTRZANKA_OD_ZRODLA	0.5	0.9	0.7
SKAWA OD ZRODLA DO POZOGI	0.5	0.9	0.7
SKAWAODPOZOGIDOMALEJOWKI	0.5	0.9	0.7
OD_MALEJOWKI_DO_BYSTRZANKI	0.5	0.9	0.7
OD_BYSTRZANKI_DO_OSIELCA	0.5	0.9	0.7

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Once all the data are filled in you can perform initial simulations.

3. Running the model

3.1. Initial simulations (non-calibrated)

The precipitation data provided for the model come from Global Precipitation Measurement Mission (GPM), which are satellite estimates, and radar network in Poland.

Prior to the simulations - characterize what are the uncertainties related to the estimation of precipitation from satellite and radar versus traditionally used rain gauges.

Initially perform the following simulations:

- simulation run (non-calibrated) for GPM precipitation data
- simulation run (non-calibrated) for radar precipitation data

Comment on the results from the statistical point of view of NSE values and peak discharge difference (between simulated and observed flow).

3.2. Optimization simulations (calibrated)

Now we can move to the phase of calibration of the model. As you might have noticed, the initial results of simulations are not very good.

Calibrate the model for different precipitation data sources. Perform the following calibration scenarios:

- calibrate only Curve Number values
- calibrate at the same time Curve Numbers, Initial Abstraction, and Lag Time

Evaluate the results using the same evaluation metrics as earlier. Discuss in which of these two calibration scenarios you might have more uncertainties and why.

4. Uncertainties of the model

In hydrological modeling, there are many different types of uncertainties. In a simplified way, we can state that there are uncertainties related to the input data (mostly precipitation and land cover) and representation of the catchment in the model.

Now, we would like to investigate how the applied parameters for routing elements in the model affect the discharge simulation. For these scenarios, it is suggested to save the already developed model into a new folder, so you will not overwrite the existing results.

Investigate the model for one best scenario for either GPM or radar data. Create three different scenarios where you will verify how the changes in length, slope, and Manning's n affect the simulation results.

Another aspect, which is very important, but often neglected in hydrological simulations are the antecedent moisture conditions. You can calculate them using the provided rain gauge data.

Remember that it is not about random simulations, but you must have good arguments for running the chosen scenarios!