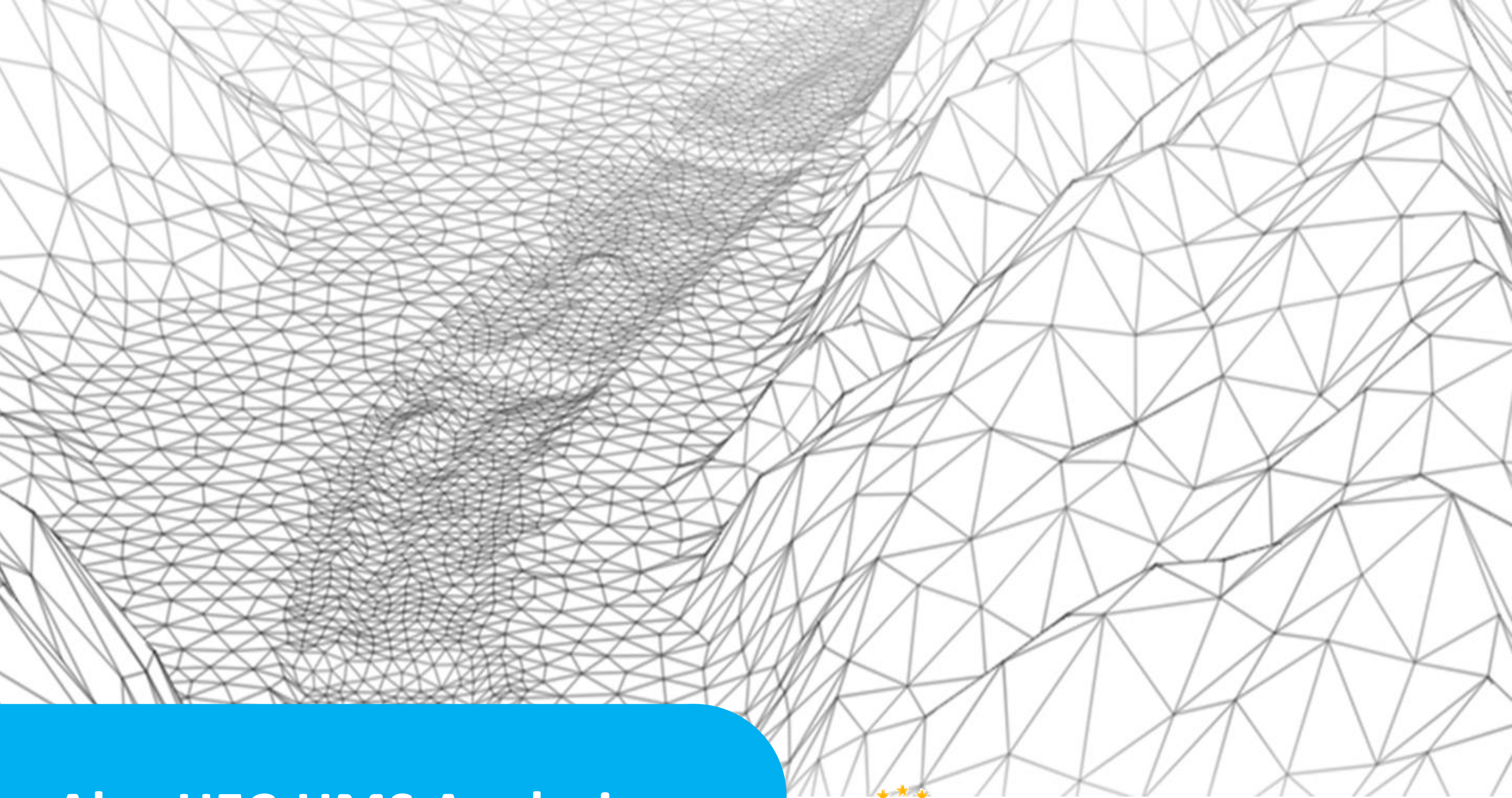

Ahr: HEC-HMS Analysis

HYDROEUROPE

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HydroEurope

WP2: Uncertainty in Advanced Hydrological and Hydraulic Modelling
WP3: Climate Change Impacts on Flash Floods
Case Study Ahr Catchment (Germany)

Uncertainty Analysis: Lumped Model – HEC-HMS

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1. Introduction

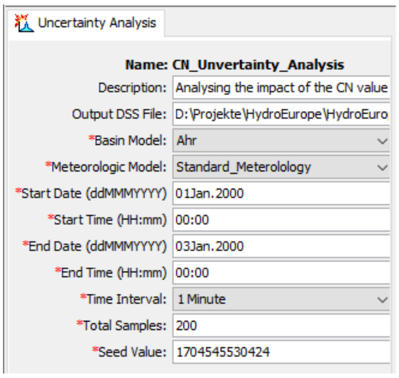
Preface HydroEurope 2024

This teaching material is part of the teaching unit dealing with “Uncertainties in Advanced Hydrological and Hydraulic Modelling” and “Climate Change Impact Impacts on Flash Floods” for the case study River Ahr catchment in Rhineland-Palatinate (Germany). This tutorial deals with the uncertainty analysis component of the HEC-HMS software for the Ahr catchment using HEC-HMS (see related tutorial “Hydrological Modelling: Lumped Model – HEC-HMS”). Target of this tutorial is an example demonstration for sensitivity and uncertainty analysis using the related tool functionality. The tutorial details are for demonstration purpose only. It is recommended to use your own HEC-HMS model to perform the related sensitivity analysis and uncertainty analysis.

2. Uncertainty Analysis for One Parameter

Step 1: Definition of the Analysis

Please create a new Uncertainty Analysis using the Uncertainty Analysis Manager (Menu Compute) and specify the related properties.

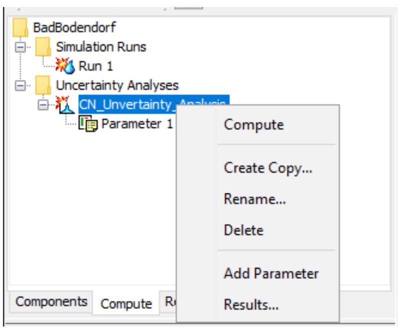


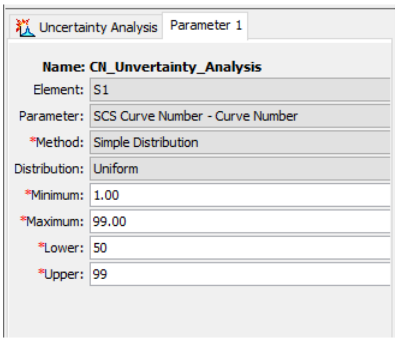
In this demonstration example the full simulation period of 48 hour and the time step/interval of 1 min of the basic mode are used. In other simulation models a smaller time window/period could be specified, e.g. considering a warm-up period.

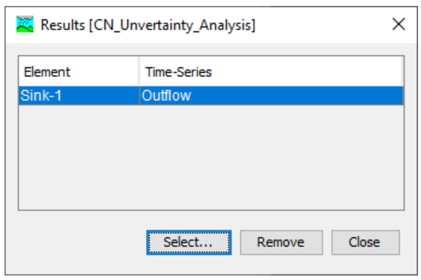
The sample size was set to 200, as we will us it for one parameter (CN value) only. As the runtime for one simulation is small, the selected 200 simulations might not require a high runtime but represents the value range 50-90 with a reasonable resolution.

Step 2: Parameter and Result Definition

The Uncertainty Analysis has parameters as input to be varied and results as output to evaluate the uncertainty. Both, the parameters as input and the results to be evaluated as output, has to be specified (). As first simple example one input parameter and one output result are used.





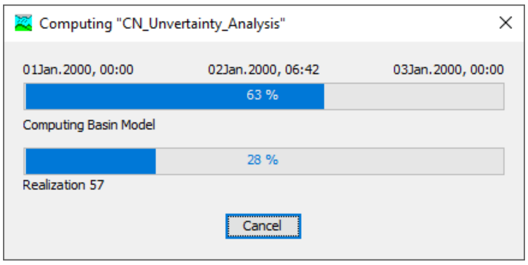


As input parameter the CN value of the catchment is specified, The CN number can be varied theoretically between 1 and 99. In this example we analyse between 50 and 99, as any value lower than 50 will not create any outflow for the defined scenario of 40 mm rainfall in one hour in the dry catchment (rainfall will be fully losses – no direct runoff). The full range of 50 to 99 is more a sensitivity analysis than an uncertainty analysis. An uncertainty analysis would consider a smaller range of CN values in respect to the reality within the Ahr catchment e.g. based on calibration results for different scenarios. The distribution of the randomized CN value is defined by uniform.

As output variable the outflow of the catchment at sink-1 (Bad Bodendorf) is chosen. The range of model result values such as peak discharge and time of peak will be analysed.

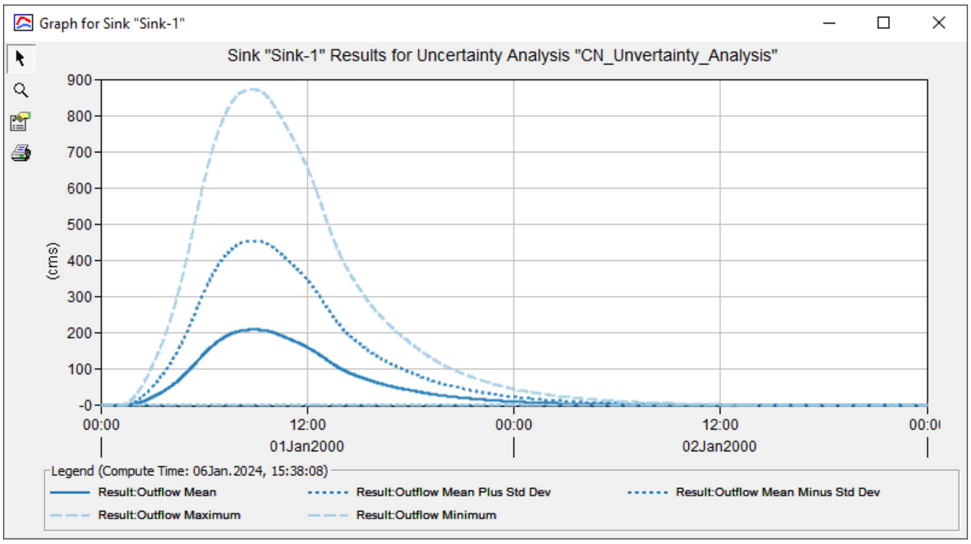
Step 3: Run the Uncertainty Analysis

After specification of the uncertainty analysis properties, the computation can be performed. 200 simulations will be performed using 200 randomized CN values based on the defined uniform distribution.



Step 4: Analysis Results

The results of the performed analysis can be viewed in tabular and graphical view. For each randomized CN value, the related outflow time series are considered. HEC-HMS shows a min/max/mean outflow time series graph for inspection:



The visual inspection underlines the physical/theoretical expectation of an impact of the CN number to the amount of outflow (by defining the losses from the total rainfall) but not changing the shape of the outflow time series, e.g. by shifting the peak discharge. The relationship of the CN number and the peak discharge as well as the outflow volume can be analysed using the tabular values for the 200 scenarios by creating a scatter plot, e.g. using Excel/LibreCalc.

The nonlinear relationship of the CN and the runoff based on the empiric defined functions are visible and demonstrate the range of the peak discharge and outflow volume for the specified rainfall (40 mm within 1 hour) in the Ahr catchment. The sensibility and uncertainty of the model in respect to the CN value (first estimation 80) require a more details analysis for this artificial scenario as well as for calibration issues.

Parameter Sampling Results for Uncertainty Analy...

Project:BadBodendorf Uncertainty Analysis:CN_Unvertainty_Analysis
Element:S1 Parameter:SCS Curve Number - Curve Number

Start of Analysis:01Jan.2000, 00:00 Basin Model: Ahr
End of Analysis: 03Jan.2000, 00:00 Meteorologic Model:Standard_Meterolology
Compute Time: 06Jan.2024, 15:38:08

Sample Number	Parameter Value
1	79.842
2	92.650
3	62.327
4	52.225
5	69.623
6	61.692
7	88.423
8	98.899
9	65.799
10	60.611
11	59.228
12	97.883
13	71.258
14	86.662
15	72.579
16	61.722
17	90.139
18	96.120
19	82.387
20	80.330

Statistic Sampling Results for Uncertainty Analys...

Project:BadBodendorf Uncertainty Analysis:CN_Unvertainty_Analysis
Element:Sink-1 Statistic:Maximum Outflow

Start of Analysis:01Jan.2000, 00:00 Basin Model: Ahr
End of Analysis: 03Jan.2000, 00:00 Meteorologic Model:Standard_Meterolology
Compute Time: 06Jan.2024, 15:38:08

Sample Number	Statistic Value (M3/S)
1	191.57
2	545.96
3	12.569
4	0.0
5	58.571
6	10.194
7	395.44
8	871.19
9	30.068
10	6.7209
11	3.3317
12	807.15
13	73.926
14	344.13
15	87.827
16	10.300
17	451.48
18	707.47
19	241.04
20	200.45

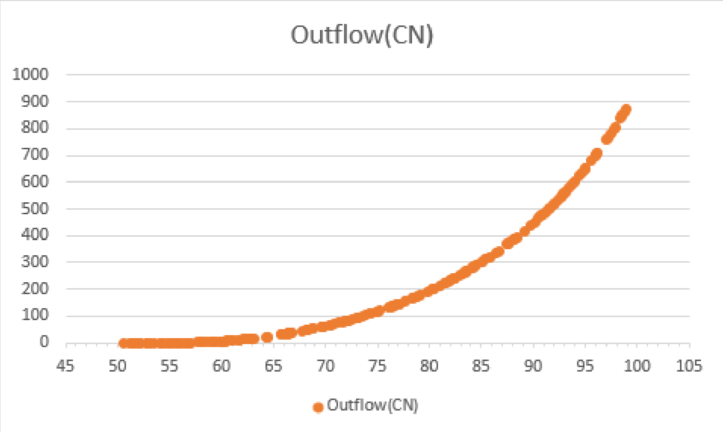
Statistic Sampling Results for Uncertainty Analysi...

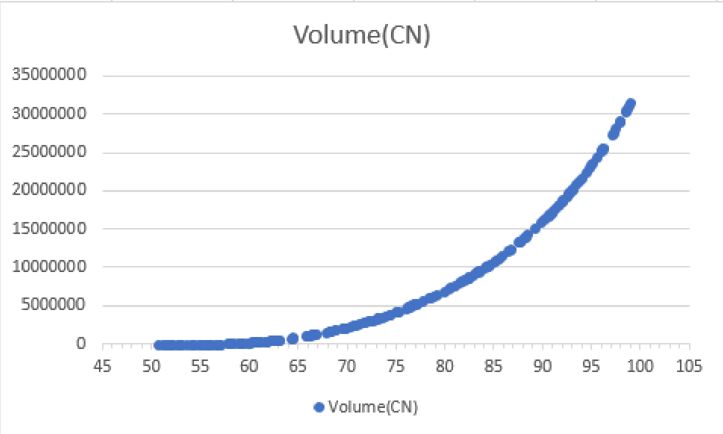
Project:BadBodendorf Uncertainty Analysis:CN_Unvertainty_Analysis
Element:Sink-1 Statistic:Outflow Volume

Start of Analysis:01Jan.2000, 00:00 Basin Model: Ahr
End of Analysis: 03Jan.2000, 00:00 Meteorologic Model:Standard_Meterolology
Compute Time: 06Jan.2024, 15:38:08

Sample Number	Statistic Value (M3)
1	6912702
2	1.9704418E7
3	453429
4	0.0
5	2113240
6	367761
7	1.4271085E7
8	3.1448698E7
9	1084776
10	242459
11	120192
12	2.9135368E7
13	2667294
14	1.2418961E7
15	3168890
16	371568
17	1.6293795E7
18	2.5535856E7
19	8697998
20	7233219

	A	B	C	D
1	1	79.84	191.57	6912702
2	2	92.65	545.96	1.97E+07
3	3	62.33	12.57	453429
4	4	52.23	0.00	0
5	5	69.62	58.57	2113240
6	6	61.69	10.19	367761
7	7	88.42	395.44	1.43E+07
8	8	98.90	871.19	3.14E+07
9	9	65.80	30.07	1084776
10	10	60.61	6.72	242459
11	11	59.23	3.33	120192
12	12	97.88	807.15	2.91E+07
13	13	71.26	73.93	2667294
14	14	86.66	344.13	1.24E+07
15	15	72.58	87.83	3168890
16	16	61.72	10.30	371568
17	17	90.14	451.48	1.63E+07
18	18	96.12	707.47	2.55E+07
19	19	82.39	241.04	8697998
20	20	80.33	200.45	7233219
21	21	91.93	517.34	1.87E+07
22	22	97.42	779.69	2.81E+07
23	23	66.50	34.57	1247376
24	24	60.02	5.13	185142
25	25	56.94	0.31	11088
26	26	92.87	554.92	2.00E+07
27	27	73.05	93.07	3358058
28	28	66.50	34.53	1245632
29	29	55.68	0.00	0
30	30	54.79	0.00	0
31	31	82.90	252.04	9095236

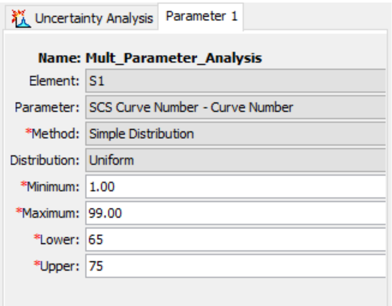


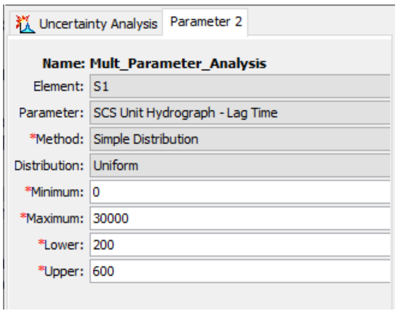


3. Uncertainty Analysis for several Parameters

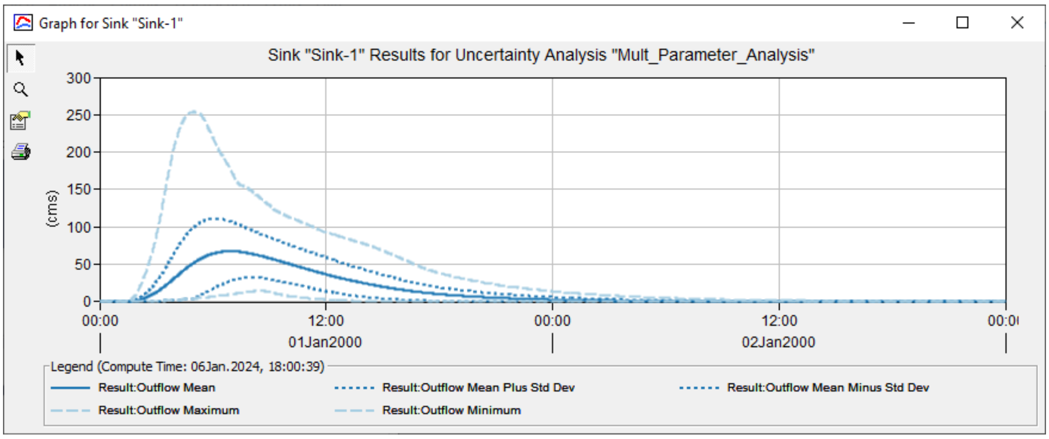
Step 1: Multi-Parameter Analysis

Second demonstration example is a multi-parameter analysis for the simple HEC-HMS Ahr catchment model. Besides the CN number the lag time will be used as additional parameter. Other parameters such as the peak rate factor should also be considered in the analysis of the Ahr catchment model. This tutorial deals with one catchment for the Bad Bodendorf gauge. The number of parameters as well as the level of complexity will increase with the number of sub-catchments. The range for the CN number is defined in this tutorial by 75 to 85, the range of the lag time by 200 min to 600 min for the Ahr catchment .





The results demonstrate the combination of the two parameters.



The complexity of interpretation is increasing by the number of parameters. The lag time has an impact to the shape of the outflow including peak discharge and time of peak. The chosen range of values has also an important impact to the shown min/max as well as mean +/- standard deviation curves. Physical insight and plausibility are helpful expertise for the interpretation of the results, which are out of the scope of this tutorial to demonstrate the functionality of the related HEC-HMS tutorial.