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Institute of Hydraulic Engineering and Water Resources Management
RWTH AACHEN UNIVERSITY

Climate and environment

FlashFloodBreaker

Runoff modeling using the Rain-On-Grid method in TELEMAC 2D

FlashFloodBreaker
Integrated simulation of pluvial fluvial flood events

Influence of the spatial CN-value distribution on the water depth

Motivation and Methods

Heavy rainfall can cause flash floods especially in urbanized and mountainous areas, where the ground is impervious and cannot hold back much water. In Germany, one of the most densely populated areas is the Ruhr area which in parts coincides with the catchment area of the Emscher River. A sub-area of this, the Rossbach sub-catchment (see Fig. 1 on the right), is chosen in this work to take a closer look at the modeling parameters for the generation of runoff in case of a heavy rain fall event via the Curve Number Method of the (former) Soil Conservation Service of the USA (SCS-CN method).

In this method, the infiltration capability soil is summarized by the so-called Curve Number (CN), which can range from 0 (infinite infiltration capacity) to 100 (no infiltration). The influences of e.g. former rainfall which affect the soil moisture are summarized by another parameter, the Antecedent Moisture Conditions (abbrev.: AMC) [1].

In the following test cases the water depth distribution in the Rossbach sub-catchment depending on the spatial discretization level of the CN-value was investigated. For this three different spatial discretization approaches were used:

- Average approach: one average CN-value for the whole sub-catchment area was used
- Two-area approach: the sub-catchment area is separated into urbanized and non-urbanized area with one CN-value each
- Normal approach: the CN-value is determined based on satellite ground data

These cases were calculated and evaluated for all three AMC (I: dry, II: average and III: wet).

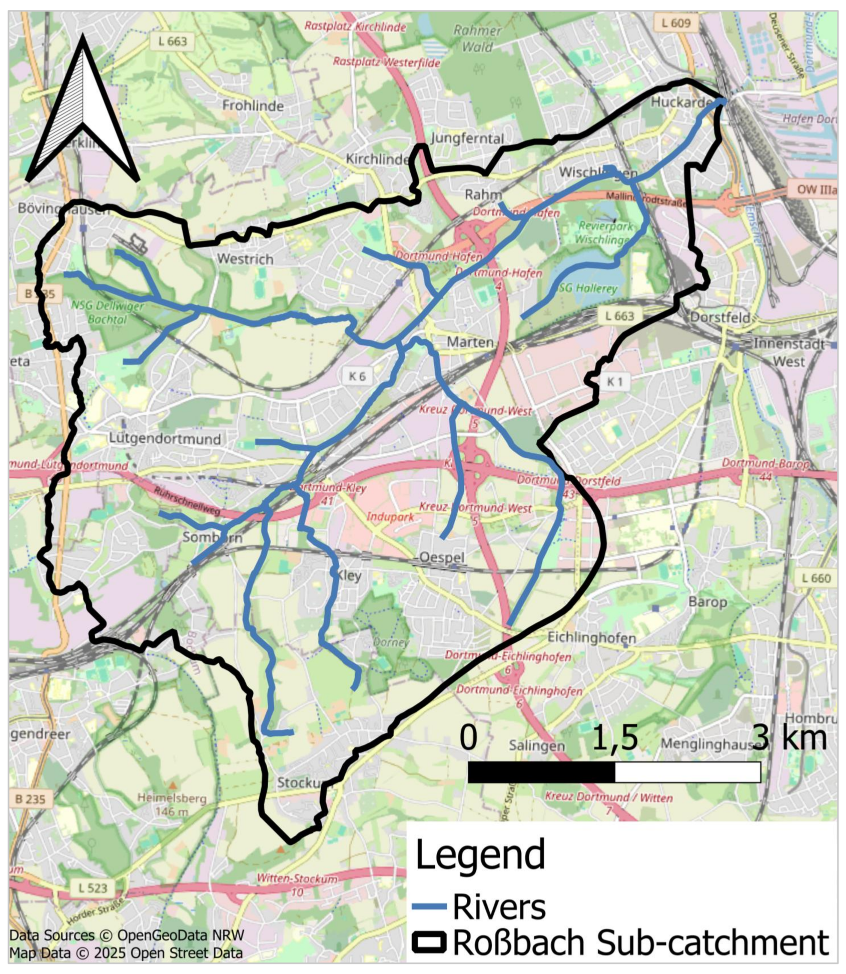

Fig. 1: Study area

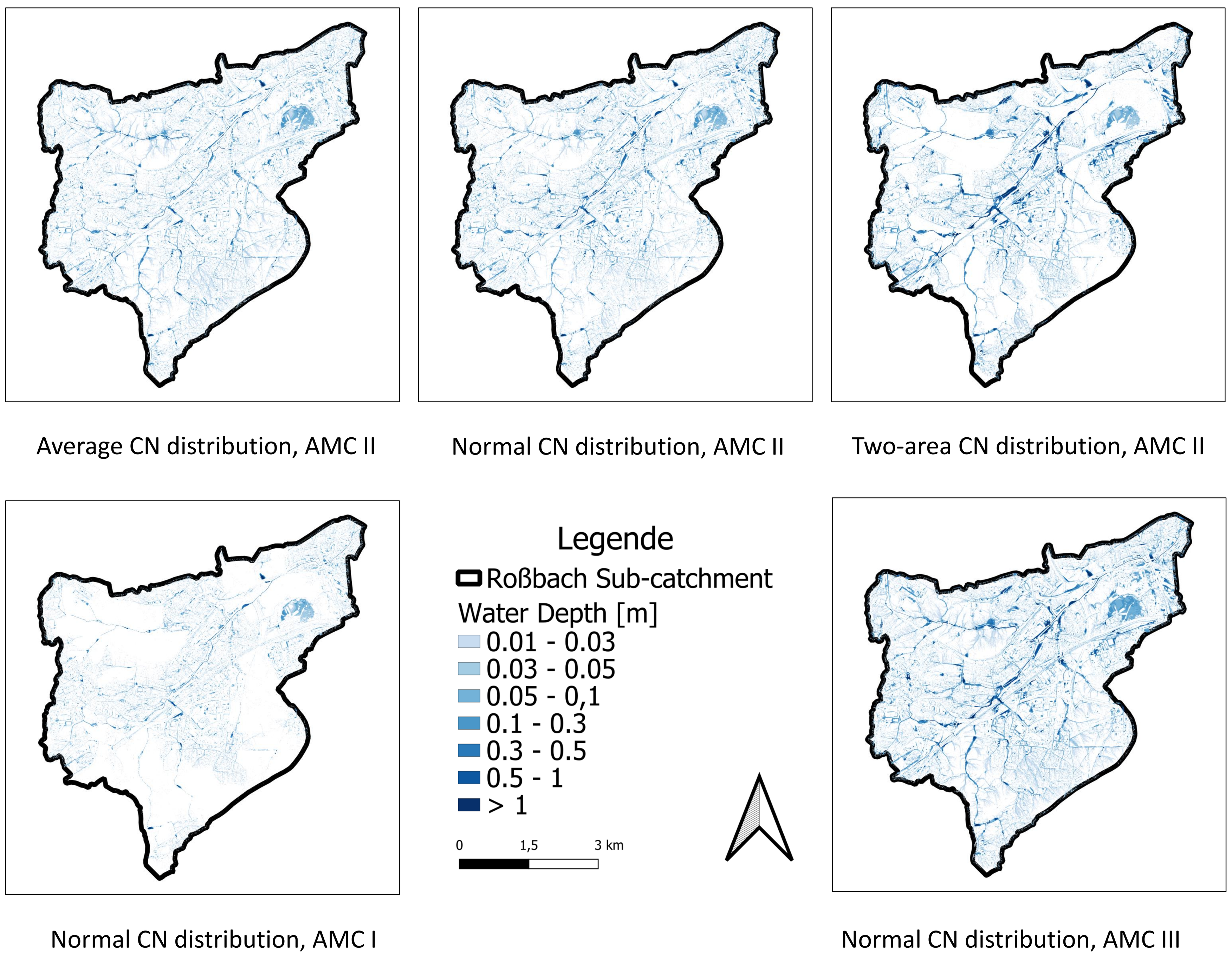

Fig. 2: Water depth distribution after 4 hours of 50 mm/h rain

Results and Conclusion

Comparing the water depth distributions, a few main differences can be noticed:

- The influence of the AMC is especially large for CN-values in the middle range (30 to 80)
- The water depth distribution in the sub-catchment is not simulated well with an averaged CN-value
- The choice of the spatial distribution of the CN-value is important for the water depth distribution

The spatial distribution of the CN-values should be considered as well since it can affect the distribution of the water in the catchment area strongly. In total, the two-area distribution approach performed better than the satellite data-based approach on historical examples. However, these differences might also originate in the higher CN-values for the urbanized areas in the two-area approach. Still, when capturing the main structures in a catchment correctly, a rougher spatial discretization still leads to rather accurate results with less effort in the preprocessing.

Nevertheless, the SCS-CN method also has many drawbacks. For example, the re-infiltration and water balance are not represented well as reported in other studies [2], [3]. But the total effect of these drawbacks could not be quantified in this study since other modeling challenges in this sub-catchment area like bridges and pumps were not included in the model yet. If these issues have been resolved, a new quantitative investigation of the impact of such drawbacks in urbanized areas should be done.

Sources:
[1] Ligier, Pierre-Louis. "Implementation of a rainfall-runoff model in TELEMAC-2D." *Proceedings of the XXIIIrd TELEMAC-MASCARET User Conference*. Vol. 11. 2016.
[2] Broich, Karl, et al. "Using TELEMAC-2D for hydrodynamic modeling of rainfall-runoff." *Proceedings of the 26th TELEMAC-MASCARET User Conference, Toulouse, France*. 2019.
[3] Saksena, Siddharth, Venkatesh Merwade, and Peter J. Singhofen. "Flood inundation modeling and mapping by integrating surface and subsurface hydrology with river hydrodynamics." *Journal of Hydrology* 575 (2019): 1155-1177

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