FACTSHEET RISK ASSESSMENT AND MAPPING ACTIVITIES

Heavy rain hazard map (simplified hydrodynamic simulations with HiPIMS)

Where was it implemented?

Germany, Saxony, Landwasser catchment, municipalities Oderwitz and Leutersdorf-Spitzkunnersdorf

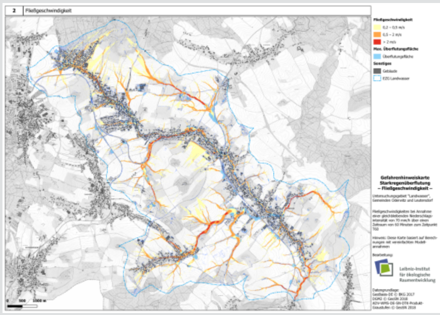
Problem/background

Past heavy rain events were often characterised by convective thunderstorms during the early summer months with different magnitudes (last events in Oderwitz: 2013 and in Spitzkunnersdorf: 2017). The catchments reacted very fast with just a few minutes remaining for warnings (esp. in Spitzkunnersdorf). Flood forecasts based on water level measurements are impossible.

Flooding processes are complex and encompass “classical” flash flooding along the watercourses of the Spitzkunnersdorfer Wasser and the Landwasser as well as river-independent surface runoff mainly from agricultural areas, entering the built-up areas. Often the runoff causes soil erosion on the cropland, transports it and deposits the soil material as mud on the streets, in gardens as well as in the buildings of the villages. The combination of an unfavourable geographical situation, the high vulnerability of the historic buildings and the traumatic and existential experiences of the villagers with these floods made recovery and preventive measures urgently necessary.

Hazard and risk maps are essential planning tools for the whole risk management process.

Map example:



Description of methodological background and outcomes

The hydrodynamic model HiPIMS solves the fully dynamic form of the shallow water equation based on a finite volume approach on a regular grid. Details about the model and examples are given in Smith & Liang (2013), Liang & Smith (2014), Smith et al. (2015) and Liang et al. (2016).

A uniform or gridded rain is used as driving input and routed over the surface of a digital elevation model. Currently there is no infiltration approach implemented, i.e. the runoff coefficient is 1. To account for losses, a global drainage/loss rate can be set. The Gauckler-Manning-Strickler hydraulic roughness value can be set for the whole domain or on a raster basis.

The model runs on CPU as well as on GPU. The runtimes on GPU are very fast (minutes to hours) compared to “classic” hydraulic models of the same class (hours to days).

For the whole Landwasser catchment with an area of approx. 50 km² a screening approach was used with the following simplifications: Digital Elevation Model (DEM) was upscaled from 2 m to 4 m cell width resulting in 3 million calculation cells. Numerical precision was reduced from double (64bit) to single (32bit). No modifications of the DEM expect integration of buildings. Constant intensity rain with no spatial differentiation. Global roughness value.

Area and event characterisation

Area type Rural and urban	**Topography** Hilly
Land cover/land use distribution 10 % forest, 60 % cropland, 30 % built-up	**Event** Block rain: 60 min 70 mm/h
Receptors Buildings and streets visualised in map	**Flood type** Flash flood with mud component

Specifications of method/measure and data demands and outputs	
Level of complexity	3
Addressed SPRC element	S/P
Method group	Process-based approach
Spatial scale(s) of application	Local to regional. Raster width 1 to 5 meters, total area limited only by computer/GPU memory
Time scale/resolution	Calculation time steps: flexible/automatic, output time steps: flexible, minutes to hours
Input datasets (type and scale/resolution)	Digital Terrain Model DTM (raster, 4 m) Gauckler-Manning-Strickler hydraulic roughness (global) Precipitation time series (global, constant, 70 mm/h)
Output datasets (type and scale/resolution)	Water levels (raster, 4 m, flexible output time steps: 1 min) Flow velocities in x and y direction (raster, 4 m, flexible output time steps: 1 min) Maximum water levels (raster, 4 m, flexible output time steps: 1 min)

DESCRIPTION OF IMPLEMENTATION	
Implementation • 3/2018 to 6/2019	**Users (reported/designated)** • Municipalities Oderwitz, Leutersdorf-Spitzkunnersdorf
Initiator/responsible • IOER/RAINMAN	**Involved stakeholders** • Municipality Oderwitz • Municipality Leutersdorf-Spitzkunnersdorf

Lessons-learned	
Main success factor: • Fast setup of input data lead to quick results. • The model is free software.	**Main challenge:** • Small scale structures such as bridges, channels and ditches are “smoothed out”.
Synergies/beneficial aspects: • The simplified hydrodynamic approach gives dynamic results and requires only little more effort compared to a simple flow path analysis. • The model runs very quick and enables multiple runs with different variants (measures, parameter values, events, …)	**Conflicts/Constraints:** • The block rain is a very artificial scenario. • The high intensity rain over such a large area with no spatial differentiation leads to extreme runoff concentration in the watercourse.

Key message to others starting with a similar task	Contact
“A simplified screening with a hydrodynamic model is a good starting point for further in-depth studies with the benefit of dynamic results with water levels and flow velocities.”	Dr. Axel Sauer Leibniz Institute of Ecological Urban and Regional Development (IOER) a.sauer@ioer.de

References
Sauer, A.; Olfert, A.; Körte, L.; Ortlepp, R. (2018) An uncertain business: Mapping flood hazards caused by heavy rain. Beton- und Stahlbetonbau 113 (2018) 95–100. https://onlinelibrary.wiley.com/action/downloadSupplement?doi=10.1002%2Fbest.201800059&file=best201800059-sup-0001-suppinfo.pdf#page=95
Smith, L.S.; Liang, Q. (2013) Towards a generalised GPU/CPU shallow-flow modelling tool. Computers & Fluids 88, 334–343.
Smith, L.S.; Liang, Q.; Quinn, P.F. (2015) Towards a hydrodynamic modelling framework appropriate for applications in urban flood assessment and mitigation using heterogeneous computing. Urban Water Journal 12(1), 67–78.
Liang, Q.; Smith, L.S. (2014) A High-Performance Integrated Hydrodynamic Modelling System for Urban Flood Inundation. Journal of Hydroinformatics 17(4), 518-533.
Liang, Q.; Xia, X.; Hou, J. (2016) Catchment-scale High-resolution Flash Flood Simulation Using the GPU-based Technology. Procedia Engineering 154, 975-981.