Hydrodynamic simulation of the flash flood events in Baiersdorf and Simbach (Bavaria) – A model comparison

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Introduction

- Specifications for hydrodynamic modeling of heavy rainfall and flash floods are missing so far.
- Test of four 2D-hydrodynamic models in two steps:
  1. Test of the four models based on five benchmark tests [1].

Software

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<th>Developer</th>
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<th>Numerical method</th>
<th>Time step method</th>
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<td>(F/D/G/B) [3]</td>
<td>dynamic wave</td>
<td>finite elements</td>
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<td>P-DWave</td>
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<td>FloodArea</td>
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</table>

Simplification of the shallow water equation:
\[
\frac{\partial h}{\partial t} + \frac{\partial (hv)}{\partial x} + \frac{\partial (hv)}{\partial y} = 0
\]

Rainfall-runoff-model

- Usage of the SCS-CN-method to generate surface runoff (effective rainfall data) with TELEMAC-2D [7].
- Later in the project, hydrological models will be used to generate these data.

Results

Baiersdorf (Fig. 5a and Fig. 6a):
- Flooded area in a range between 60 % (\( t \)) and 67 % (\( f \))
- Differences between the models in the outflow area (different interpretation of boundary conditions) and in the depiction of small structures (culverts, trenches, etc.)
- Underestimation of high water marks, but differences are similar to Simulation a. Inn (~ 50 cm vs. ~ 100 cm).

Sembach a. Inn (Fig. 5b and Fig. 6b):
- Flooded area in a range between 38 % (\( H \)) and 44 % (\( F \)).
- Differences between the models especially in the accumulation area before culverts in the river of Simbach.
- Underestimation of high water marks, as the real dam failure was not simulated; overestimation of high water marks with not simulated effective pumping equations.

Risk areas

- Precipitation

Precipitation

RADOLAN-YW-Product [6]:
- 1 km² and 5 min resolution
- Calibration on station data

Baiersdorf:
- Max: 7.5 mm/min
- Sum.: 67 mm

Sembach a. Inn:
- Max: 9.7 mm/min
- Sum.: 135 mm

Rainfall-runoff model

- Usage of the SCS-CN-method to generate surface runoff (effective rainfall data) with TELEMAC-2D [7].
- Later in the project, hydrological models will be used to generate these data.

Conclusion

- Results show model comparison, no calibration to real flash flood events or measured high water marks.
- Detailed depiction of culverts is very important (disadvantage of finite element method with regular grid resolution).
- The water levels in the channel can obviously be depicted wrong with kinematic wave as basic equation.
- All four models are suitable for simulating flash floods, but peculiarities of the models must be considered in simulation.

Advantages and disadvantages of the models

HYDRO AS-2D
- flexible and stable usage
- right connection to SMS (preprocessor)

TELEMAC-2D
- good parallelization (HPC)
- open source
- high learning curve
- long computational time

P-DWave
- easy data treatment (ASCII)
- just usable for surface runoff

FloodArea
- direct coupling with ArcGIS

Literature