Chair of Hydrology and River Basin Management
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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].
  (2) Test of the four models based on two real flash flood events in Baiersdorf (21. July 2007) and Simbach a. Inn (31. May/1. June 2016).

Software

	Developer	Equation	Numerical method	Time step method
HYDRO_AS-2D	Hydrotec [2]	dynamic wave	finite volume	explicit
TELEMAC-2D	Developer consortium (F/D/GB) [3]	dynamic wave	finite elements	implicit
P-DWave	Dr. Jorge Leandro [4]	diffusive wave	finite volume	explicit
FloodArea	geomer GmbH [5]	kinematic wave	finite differences	explicit

Simplification of the shallow water equation: $\frac{\partial\left(\frac{Q^2}{A}\right)}{\partial x} + \frac{\partial Q}{\partial t} + gA\frac{\partial h}{\partial x} - gA(I_E - I_S) = 0 \quad \frac{\partial Q}{\partial x} + \frac{\partial A}{\partial t} = 0$

Precipitation

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

Baiersdorf:
- Max: 7.5 mm/5min
- Sum.: 67 mm

Simbach a. Inn:
- Max: 9.7 mm/5min
- Sum.: 153 mm

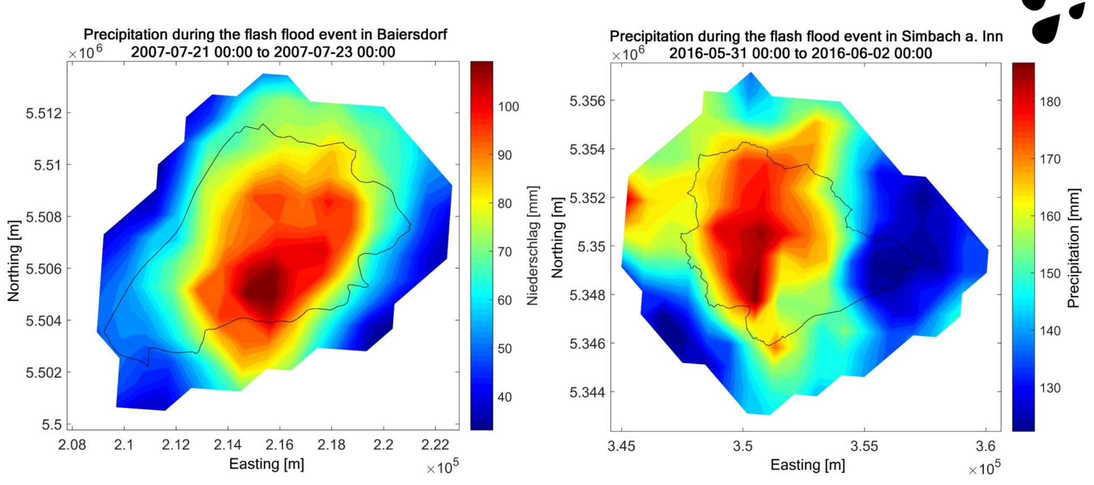


Fig. 3: Total Radolan-Precipitation for the heavy rainfall events in Baiersdorf (left) and Simbach a. Inn (right).

Model areas

- Coarse simulation of the catchment area to generate inflow and surface runoff for the city area.
- Resolution of Catchment area: 5 x 5 m with TELEMAC-2D, City area: 2 x 2 m with all models

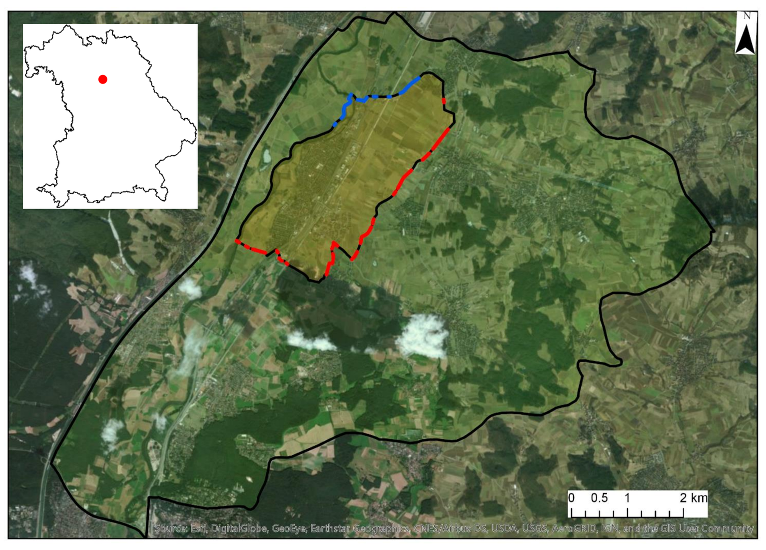


Fig. 1: Catchment area (green), city area (yellow), inflows (red) and outflows (blue) of Baiersdorf.

Baiersdorf:
Catchment area: 58.4 km² (2.6 Mio. nodes)
City area: 6.65 km² (1.7 Mio. nodes)

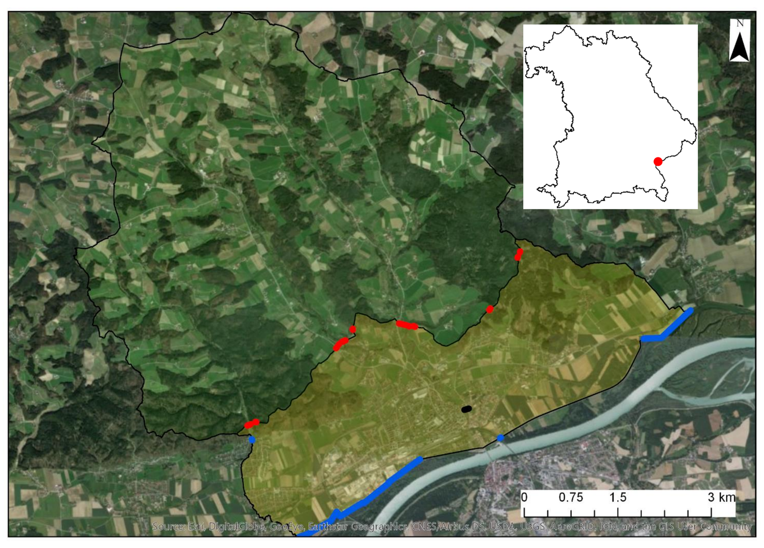


Fig. 2: Catchment area (green), city area (yellow), inflows (red) and outflows (blue) of Simbach a. Inn.

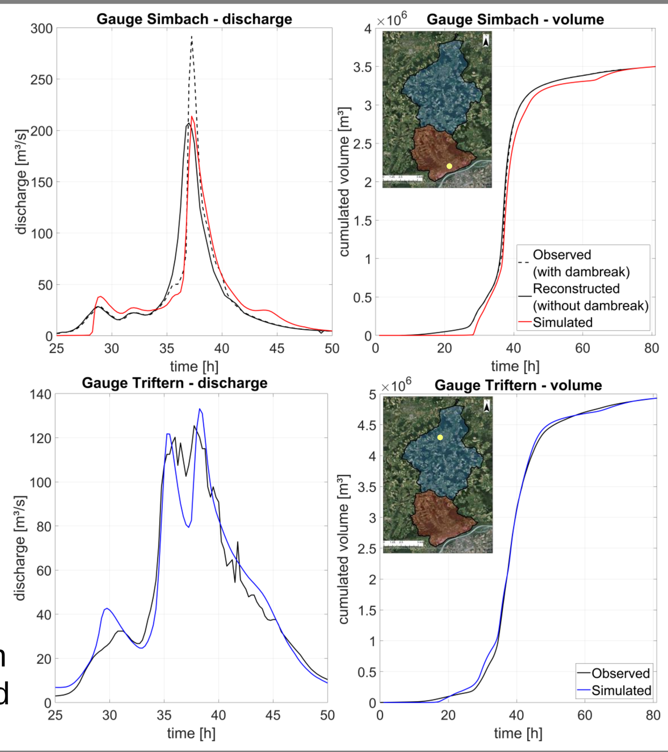
Simbach a. Inn:
Catchment area: 45.9 km² (2.0 Mio. nodes)
City area: 14.5 km² (3.7 Mio. nodes)

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.

	Obs.	Sim.	Dev.
Peak [m³/s]	207.2	213.9	+ 3.2 %
Time Peaks [h]	37	37.25	+ 15 min
Volume [Mio. m³]	3.5	3.499	- 0.03 %

	Obs.	Sim.	Dev.
Peak 1 [m³/s]	120.3	121.8	+ 1.3 %
Peak 2 [m³/s]	125.5	133.2	+ 6.1 %
Time Peak 1 [h]	36	35.25	- 45 min
Time Peak 2 [h]	37.75	38.25	+ 30 min
Volume [Mio. m³]	4.932	4.931	- 0.02 %



Tab./Fig. 4: Verification of the SCS-CN-method in the neighboring catchments of Simbach a. Inn (calibration) and Triftern (validation). Shown are the discharge and total volume on both gauges during the flash flood events.

Results

Baiersdorf (Fig. 5a and Fig. 6a):
- Flooded area in a range between 60 % (H) 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 smaller than in Simbach a. Inn (~ 50 cm vs. ~ 100 cm).

Simbach a. Inn (Fig. 5b and Fig. 6b):
- Flooded area in a range between 38 % (H) and 44 % (T).
- 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 stations.

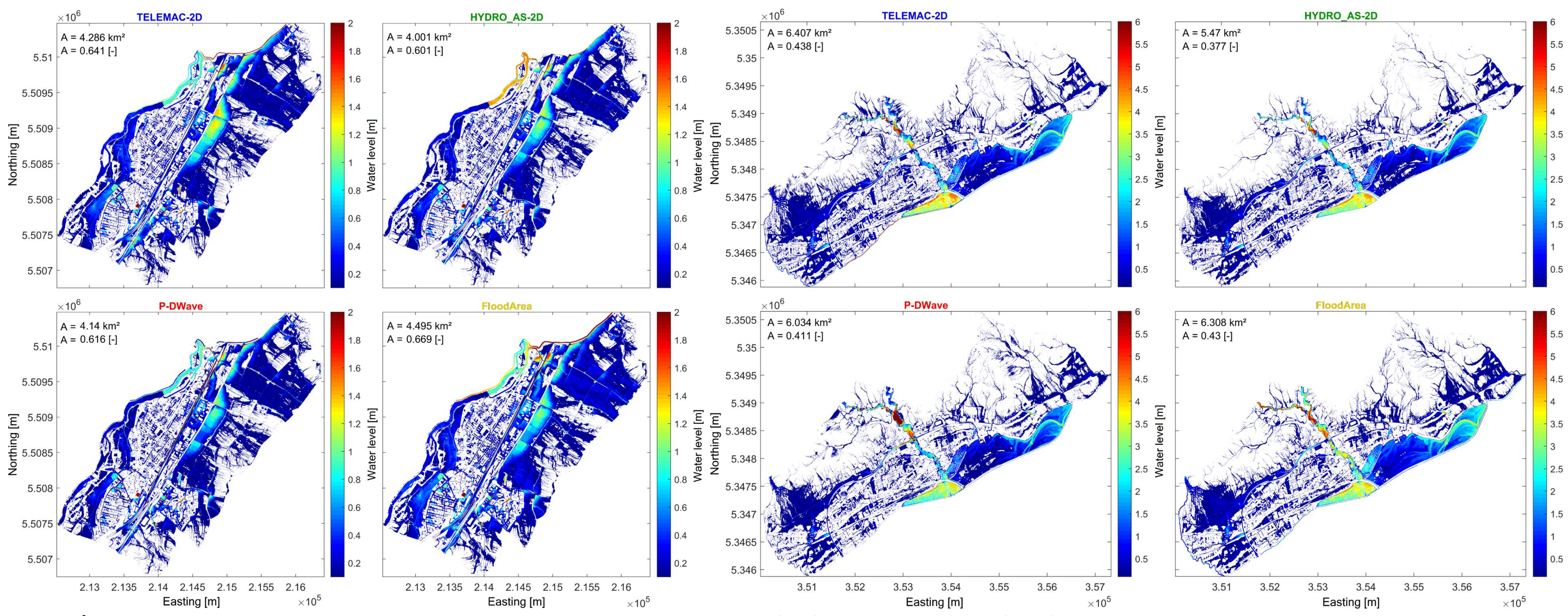


Fig. 5a/5b: Simulated maximum flooded area of the flash flood events in Baiersdorf (left) and Simbach a. Inn (right).

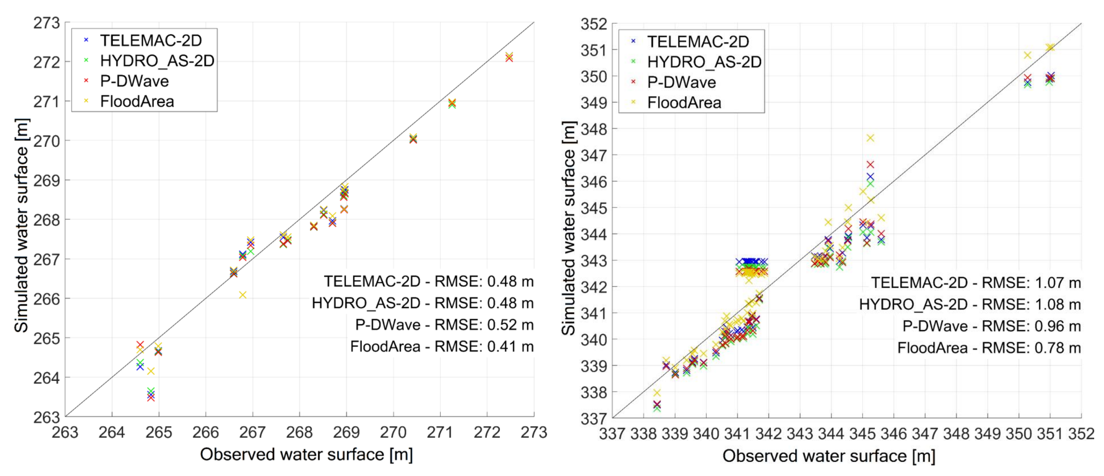


Abb. 6a/6b: Scatterplots of simulated and observed high water marks in Baiersdorf (left) and Simbach a. Inn (right).

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	TELEMAC-2D	P-DWave	FloodArea
+ flexible and stable usage	+ good parallelization (HPC) + open source	+ easy data treatment (ASCII)	+ direct coupling with ArcGIS
- rigid connection to SMS (preprocessor)	- high learning curve	- long computational time	- just useable for surface runoff

Literature

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