Chair for Hydrology and River Basin Management
Department of Civil, Geo and Environmental Engineering
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Deficits and Solution Approaches of Measuring and Model Validation of Flash Floods in Bavaria

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Working plan of the hydrological modelling in the project HiOS to investigate and evaluate deficits of the hydrological flash flood modelling.

test catchments with historical flash flood event (see figure 1)

model setup (raster based, conceptional) → **calibration / validation** of the models to reproduce the **water balance** → test of a **event-based calibration** to simulate flash flood events → **Test of hydrological approaches**:
- Runoff generation (infiltration)
- Runoff concentration
- Routing

validation catchments with historical flash flood event

analysis of the pseudo-calibrated radar **RADOLAN-YW** data (5-min. timestep) → Selection of the validation catchments and **model setup** → **validation** of the event-based calibration using **historical flash flood events** → **Study about necessary resolution**:
- Spatial: 10, 25, 50, 100 and 1000 m
- Temporal: 5, 15, 30 and 60 min.

evaluation catchments for assessment without historical flash flood event

programming of **tools for automatized model setup** of the catchment data files → **model setup** for evaluation catchments → **regionalization** of event-based parametrization dependent on large-scale natural regions of Bavaria → **Calibration** of all models to water balance and subsequently imprint of regionalized flash flood parameters

→ Calibration of all models on demands

Evaluation of **decisive discharge** with scenarios shown in figure 7

Delivery of input hydrographs to hydrodynamic modelling

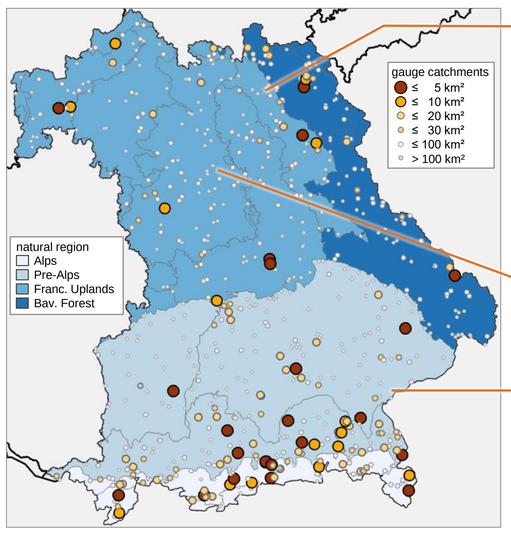

Figure 1: catchment areas of the Bavarian gauge network in their natural regions. Upper right: Overview of test catchments.
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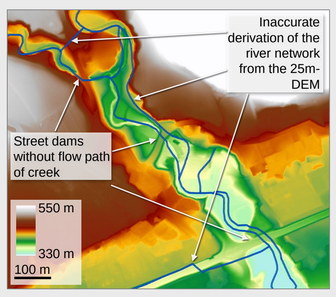

Figure 3 (right): 1m-DEM of the Simbach catchment showing street dams as well as the river network (FGN 25).
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- Evaluation of decisive flash flood discharges is a **hypothetic event** using **many assumptions** e.g. land use, soil moisture, spatial and temporal precipitation distribution (figure 7)
- Depiction has to show potential **variability**, but stay in layman's terms to be **commonly understandable**
- Sediments and drift wood is important.
- Defined communication paths to use **short warning times** efficiently.

Depiction and Communication of Modelling Results

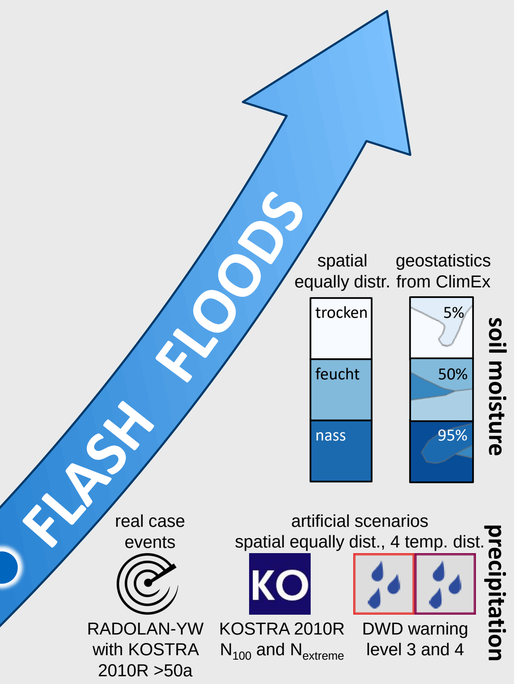


Figure 7: precipitation and soil moisture scenarios in HiOS. Overall the combinations result in 672 realizations.

- **Flash floods have been not in the focus** of the flood forecast institutes
- Existing models are technically not prepared for spatial and temporal highly resolved calculations.
- **Operational service** needs short calculation times
- Modelling of flash floods causes heavily **increased calculation times** due to high resolution
- **Parallelization** is costly
- **Static flow network** is not able to reproduce surface runoff paths

Transformation in computer software

- Events in **small catchments** (A < 200 km²)
- **Complex distinction** of catchments because of large distances to gauges (see figure 1)
- Uncertainty of available data sets disturb and limit automatic model setup (see figure 3)
- Unclarity about necessary **spatial** and **temporal scales** to simulate flash floods successfully
- Detailed spatially distributed information necessary
- **Polder creation, drift wood jams, dike breaks**

Reproduction of the hydrological catchment and model scales

Model Sensitivity, Calibration and Validation

- Danger of **Overfitting** with many calibration parameters of conceptual models.
- Hydrological processes urge for **sensitivity tests** using flash flood data.
- Measured and **well documented events are not systematically listed.**
- Necessity to analyze and evaluate radar and discharge data to identify events (see figure 5).

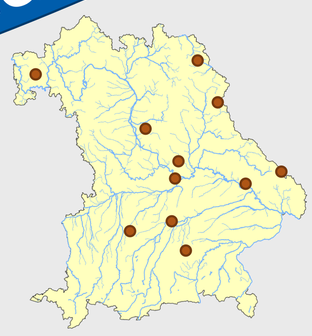
Summary of time-dependent stationary and distributed input data

- Temporal (automatic stations, 1 min.) and spatial (RADAR, 1 km²) high resolved **precipitation data exists** (figure 4b).
- Discharge data every 15 min., but only **few gauges with catchments < 10 km²** (fig. 1).
- **Soil moisture** is **rarely** measured (see figure 4a).
- **Many separated data bases** lead to varying data quality and different formats.

SET UP OF HYDROLOGICAL MODELS FOR FLASH FLOODS

Definition of relevant processes and process simulation methods

- **Extreme situation**, therefore other decisive processes than in long term simulation
- **Infiltration capacity** of the soil incl. influence of preconditions
- **Spatial runoff concentration** (spatially distributed discharge and temporal change of roughness)
- **Hydraulics in the river bed** (variable roughness and Shallow Water Equation, see figure 2)
- Decisive: **temporal dynamics**



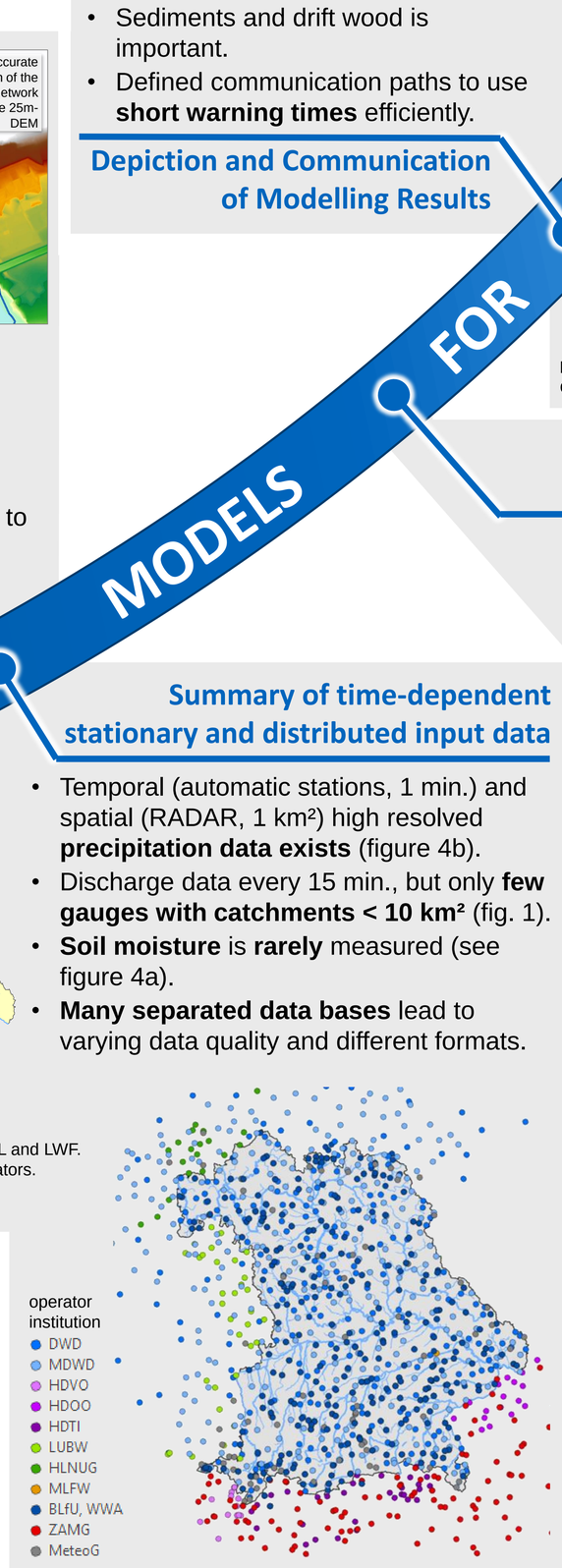


Figure 4a (above): Soil moisture measurement network of BLfL and LWF.
Figure 4b (below right): Precipitation stations of different operators.
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Figure 2: Stripped river bed of the Simbach near Steghäuser after the flash flood of 1st of June 2016.

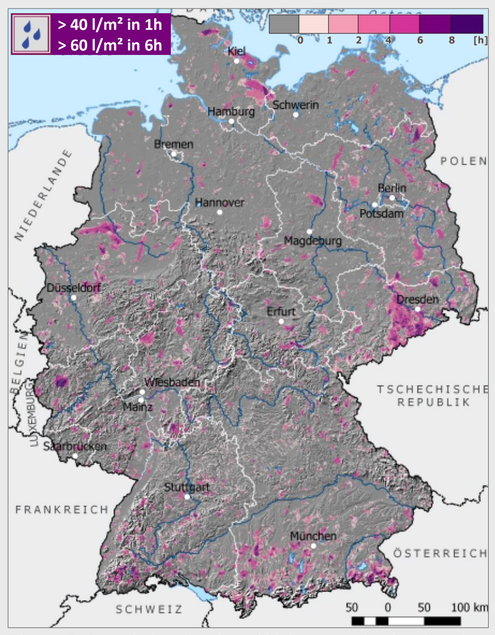

Figure 5: Cumulative duration of highest warning level against heavy precipitation of the German Weather Service (DWD) for 2001-2015, from RADOLAN-YW-Data (Becker et al. 2016).
Geodata: © GeoBasis-DE/BKG 2014,
Climate data: © Radarklimatologie v.2016.003

Sources:
Becker, A.; Hafer, M.; Junghänel, T.; Müller, H.-J.; Sterker, C.; Walawander, E. (2016): Bewertung des Starkregenrisikos in Deutschland auf der Basis von Radardaten. 10. DWD Klimatagung. Offenbach a. M.

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