Hydrological Modelling of Droughts and Stormwater Events to Develop Climate Resilient Water Management Strategies

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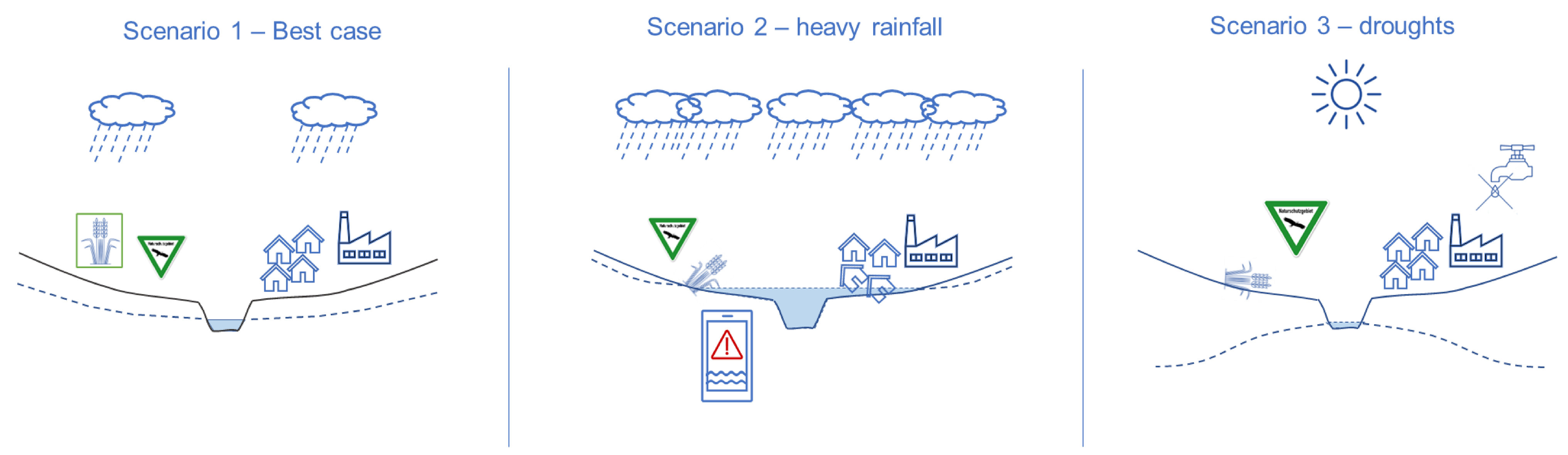
The project „KliMaWerk“

- Project aim: Development of strategies to increase the hydrological and ecological resilience of river basins to droughts and heavy rainfall events.
- Focus of this presentation: Hydrological modelling to analyse the development of the landscape water balance, the underlying processes, and likely effects of different measures and land management strategies on climate resilience.
- Study area: Lippe River Basin, North Rhine-Westphalia (Germany).

Analysis and modelling of processes

1. Understanding the extremes and their consequences
2. Development of strategies



Hydrological Modelling with SWAT+ Entire Research Area and Upscaling

SWAT+

- **Characteristics of catchment area**
  - Lippe River (4,860 km²)
  - Length of Lippe River: ~220 km (flows into the Rhine River)
  - Land use: agriculture 53%, grassland 12%, forest 19%, urban 12%
  - Controlled water transfer to the Datteln-Hamm-Canal of Ø 37% from the Lippe River streamflow; in turn a minimum river runoff of 10 m³/s is maintained

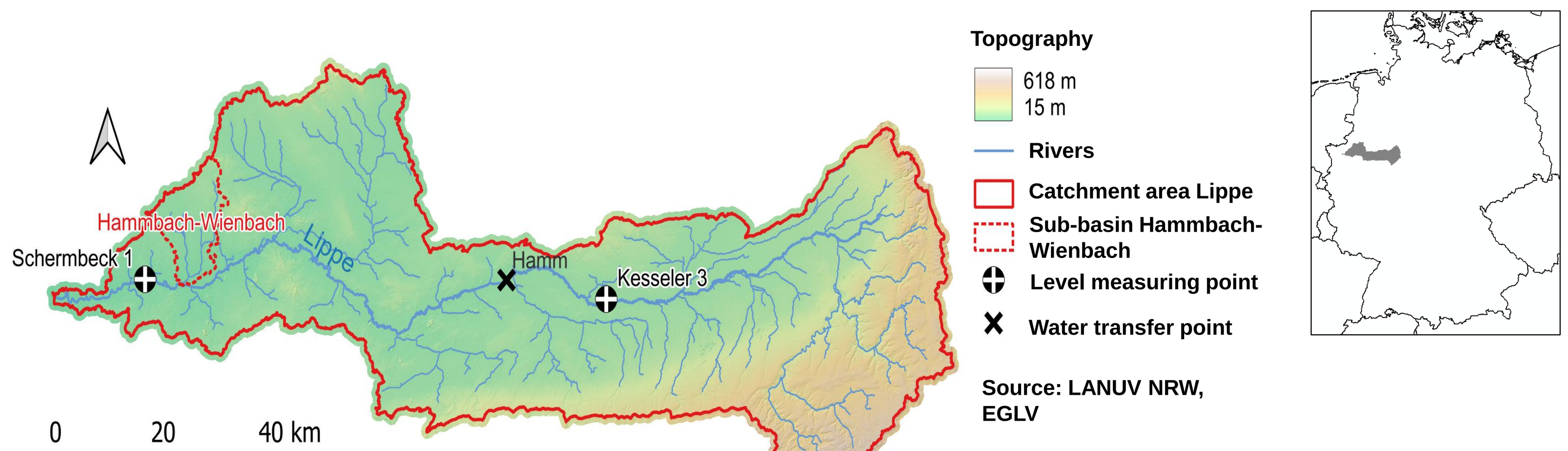
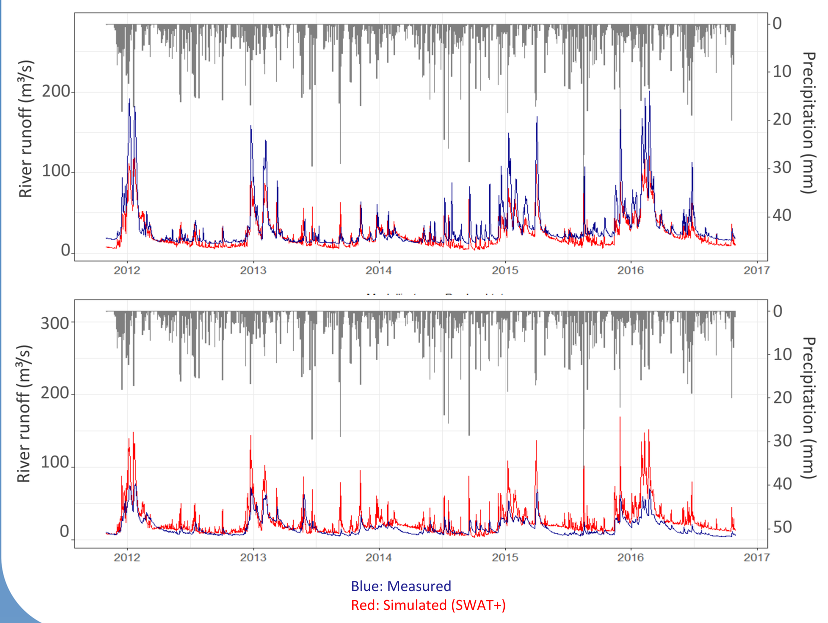


Fig.: Study area Lippe River with highlighted key features.

- **Workflow hydrological modelling**



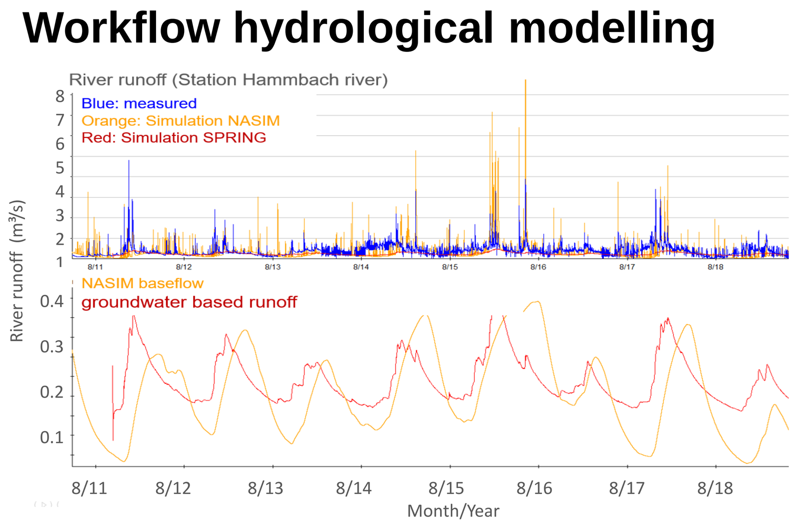
1. Model parameterisation including water transfer point Lippe River / Datteln-Hamm-Canal
2. Calibration at river gauges, not influenced by
   - Water transfer (gauge Kesseler 3)
   - Rhine River (gauge Schermbeck 1)
3. Continuous simulation at a daily time step (2011 - 2021)

Fig.: Precipitation and runoff hydrographs in the calibration period (hydrological years 2012 - 2016)

Hydrological Modelling with NASIM Sub-Basin Study

NASIM

- **Characteristics of catchment area**
  - Creek System Hammbach-Wienbach (146 km²)
  - Length of Hammbach Creek ~21 km, Wienbach Creek ~14 km
  - Land use: agriculture 57%, grassland 8%, forest 28%, urban 6%
  - Mining subsidence areas & pumping stations
  - "impermeable" Bottrop Strata (marl), different aquifers
  - Large depth to the groundwater table (20 - 70 m) in the North
- **Workflow hydrological modelling**



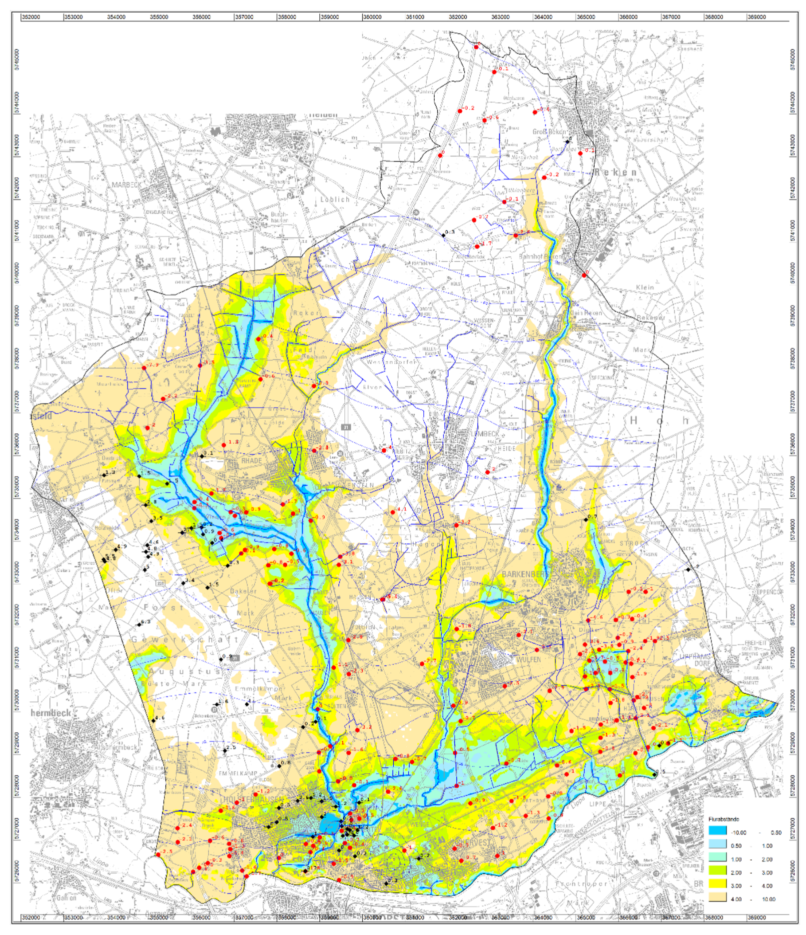
1. Model set up: parameterisation of sub-areas (natural & urban areas)
2. Coupling to groundwater flow
3. Calibration at gauging stations
4. Continuous simulations in 5-minute steps (2011 - 2021)

Fig.: Intermediate calibration results including comparison to groundwater based runoff (SPRING)

Hydrogeological Modelling with SPRING Sub-Basin Study

SPRING

- **Workflow hydrogeological modelling**

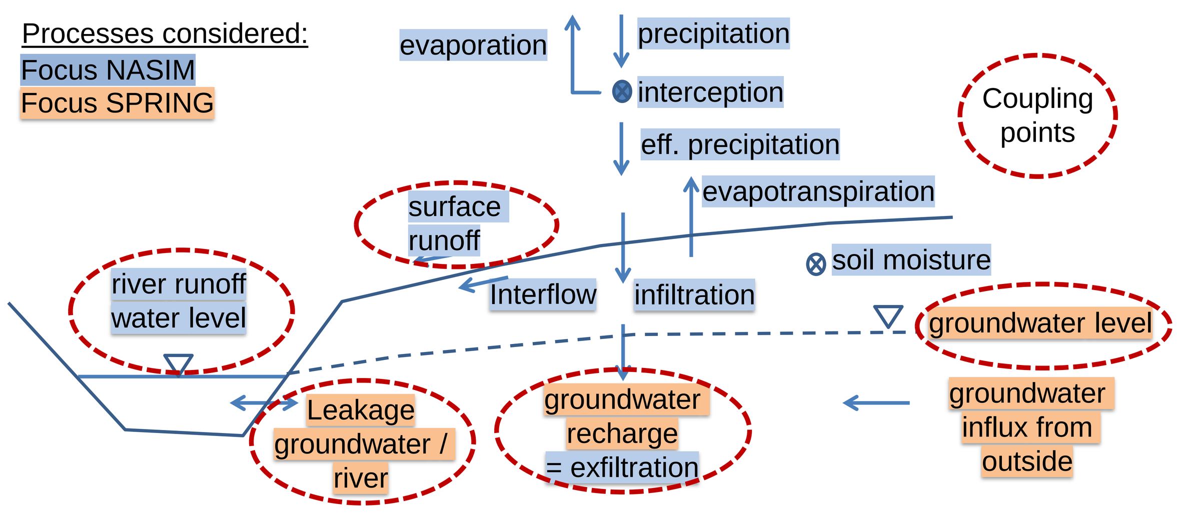


1. Set up of a 2D groundwater flow model
2. Surface water network: simplified approach for surface runoff
3. Determination of transient groundwater recharge using the integrated method RUBINFLUX (period 2011 - 2021, daily steps)
4. Steady-state and transient calibration of the model using data from groundwater level monitoring and river gauges

Fig.: Water table contour lines, depth to water table, deviation measured/modelled water levels (steady-state)

Coupling NASIM & SPRING – Workflow & Concept

- Comparison of the simulation results
- Post-processing and variation of existing model building blocks
- Exchange of model results via defined exchange files/interfaces
- Simulate the models separately (multiple iterations)
- Coupling of models during simulation at predefined coupling points



- **First steps**: Transfer of the groundwater leakage values (SPRING) to the NASIM model
- **Further coupling points:** Groundwater recharge, surface water level, surface runoff

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Project partners

EGLV Emschergenossenschaft Lippeverband; Hydrotec; eco logic; delta h Ingenieurgesellschaft; CAU Christian-Albrechts-Universität zu Kiel, Abteilung Hydrologie und Wasserwirtschaft; Universität Duisburg-Essen, Offen im Denken; Planungsbüro Koenzen Wasser und Landschaft