



# Hindcasting the 2021 flood event for the Rur river

## Sebastian Hartgring

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Prof. Dr.-Ing. Daniel Bachmann (Hochschule Magdeburg-Stendal)

Prof. Dr. Ir. Remko Uijlenhoet (TU Delft)

Dr. Elise Ragno (TU Delft)

Dr. Ir. Erik Mosselman (Deltares – TU Delft)

# My presentation of today

Thesis: *On forecasting the Rur river*

- Developing and comparing models for the Rur river
- July 2021 hindcast (RADFLOOD21) and forecasts (ICON-EU-EPS)
- Understand catchment response to floods
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Today: **focus on hindcasting the July 2021 flood event**

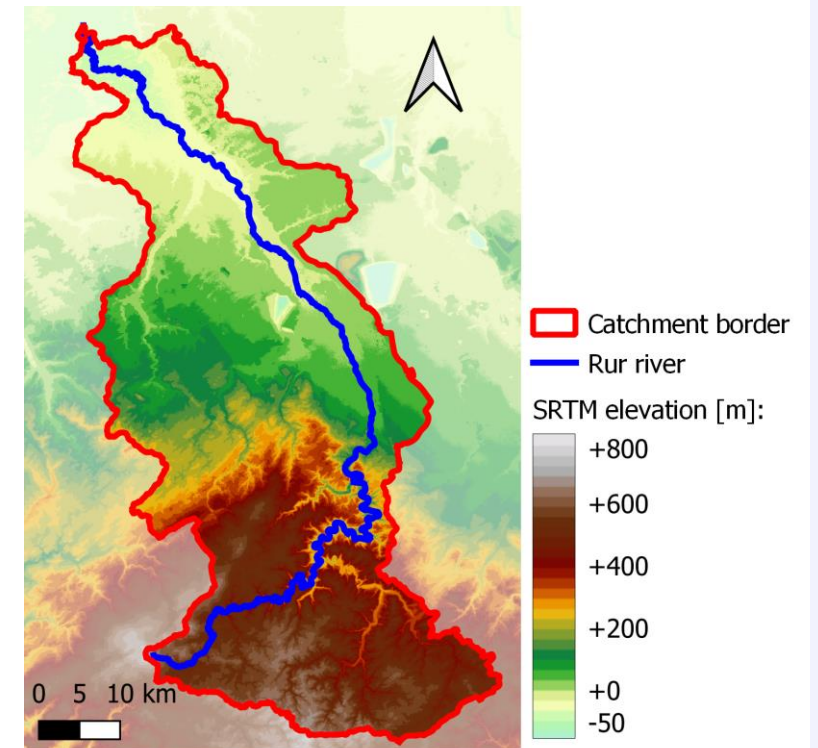
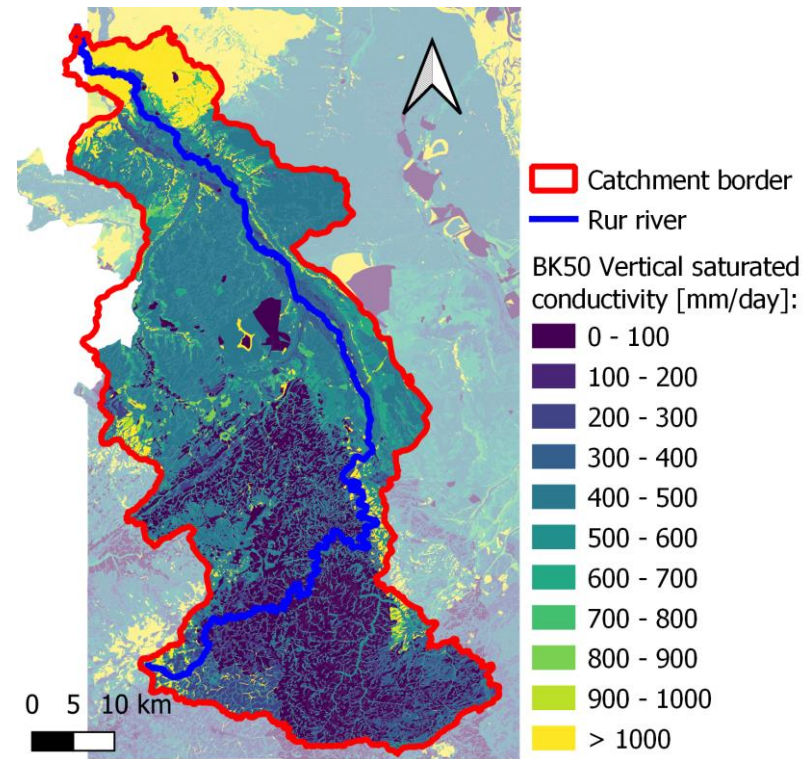
# Description of Rur catchment



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## Main characteristics

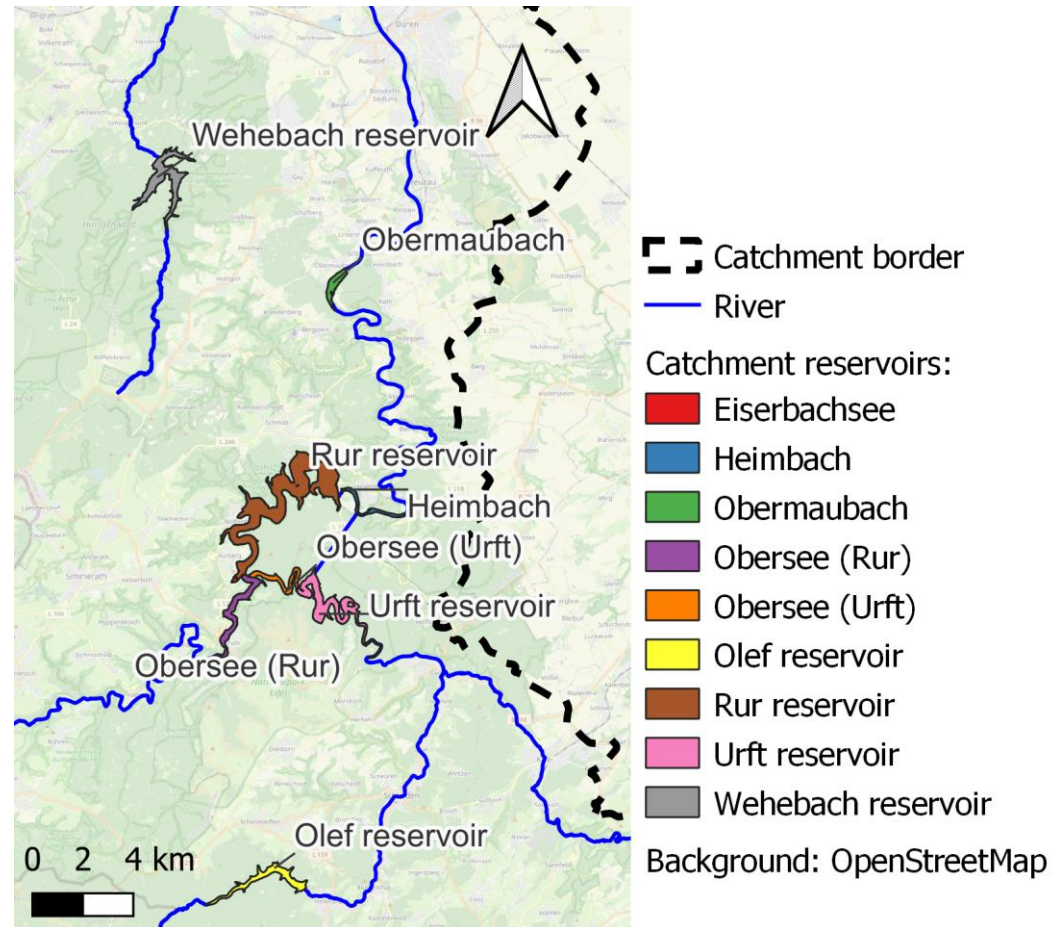
- **Eifel area versus lowlands**
- Reservoir systems
- Lignite mining



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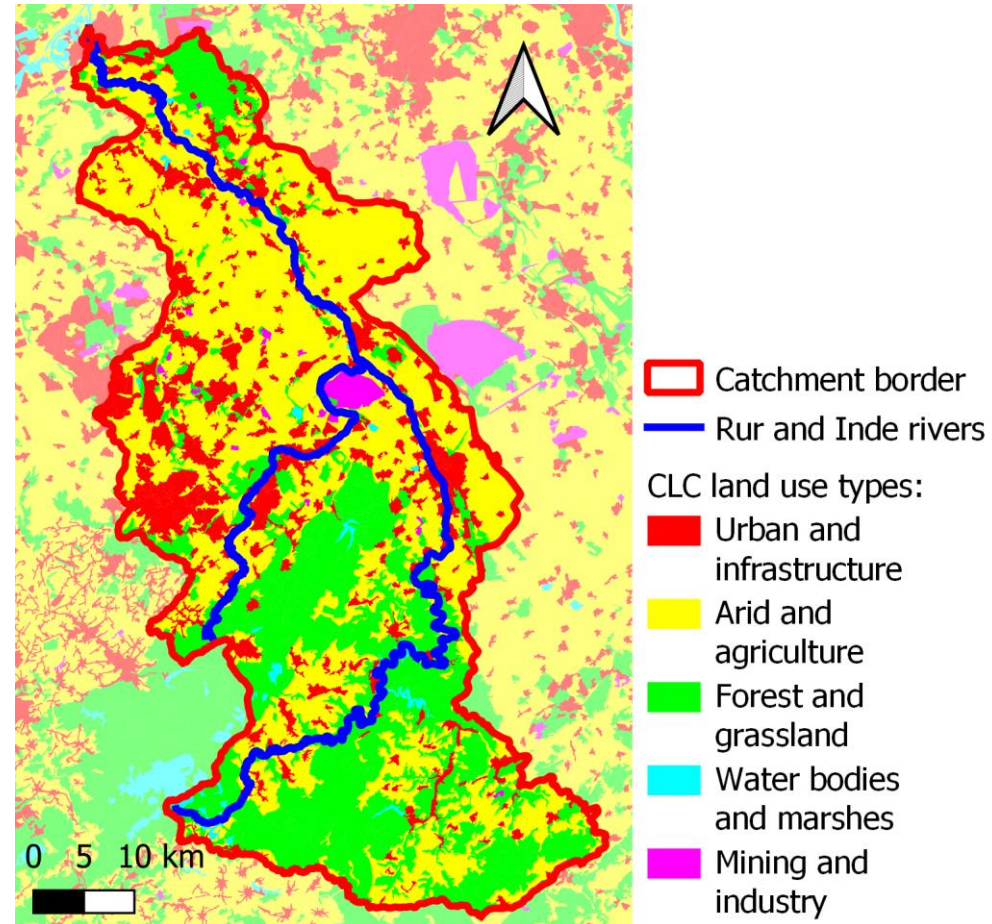
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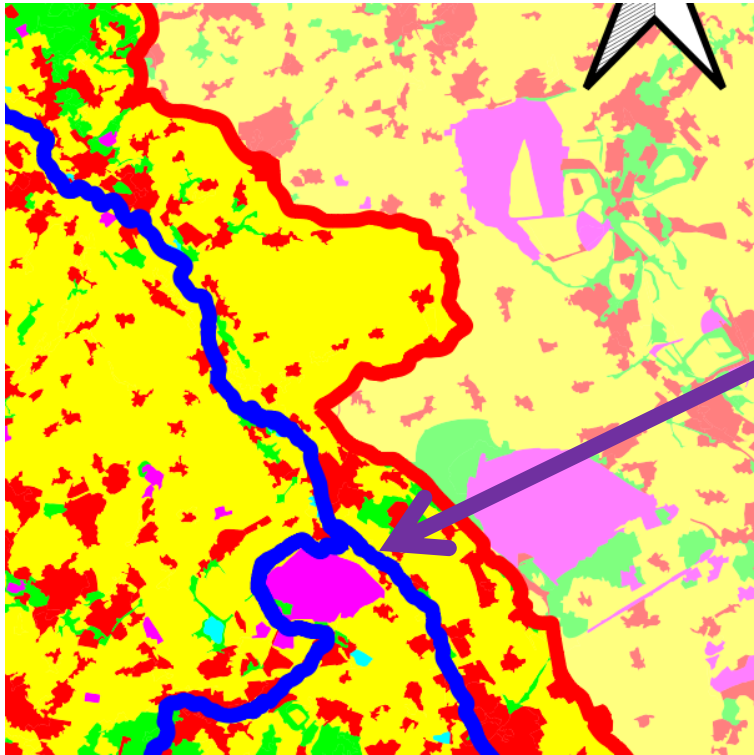
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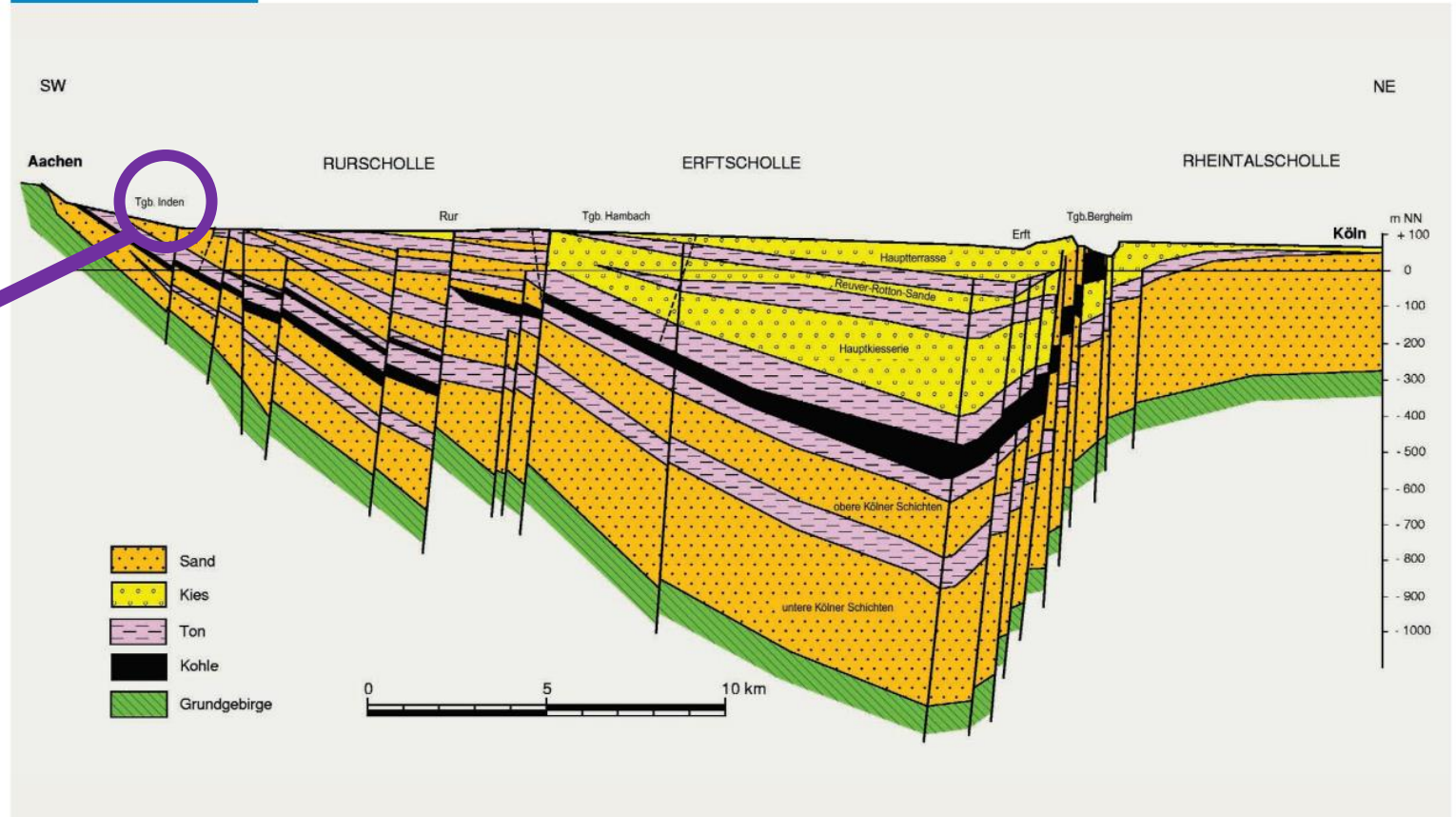




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► Abb. 2.2.1-1 Tektonische Strukturierung und Stockwerksgliederung der Niederrheinischen Bucht (schematisch)

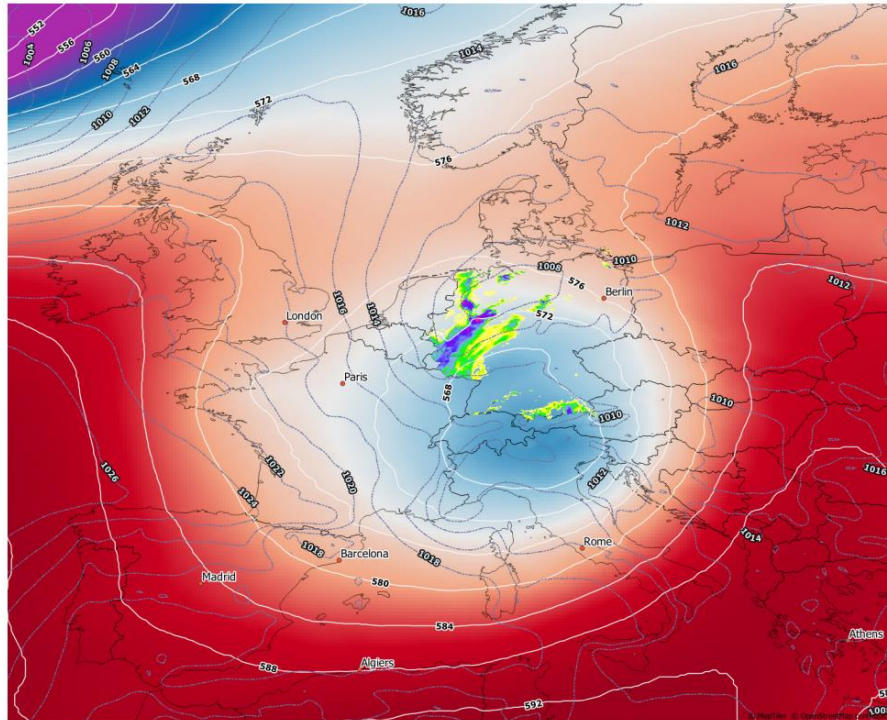


Vom Kothen, V. and Ütz, N.P. (2005). *Ergebnisbericht Rur und südliche sonstige Maaszuflüsse*. Ministerium für Umwelt, Naturschutz und Verkehr des Landes Nordrhein-Westfalen.

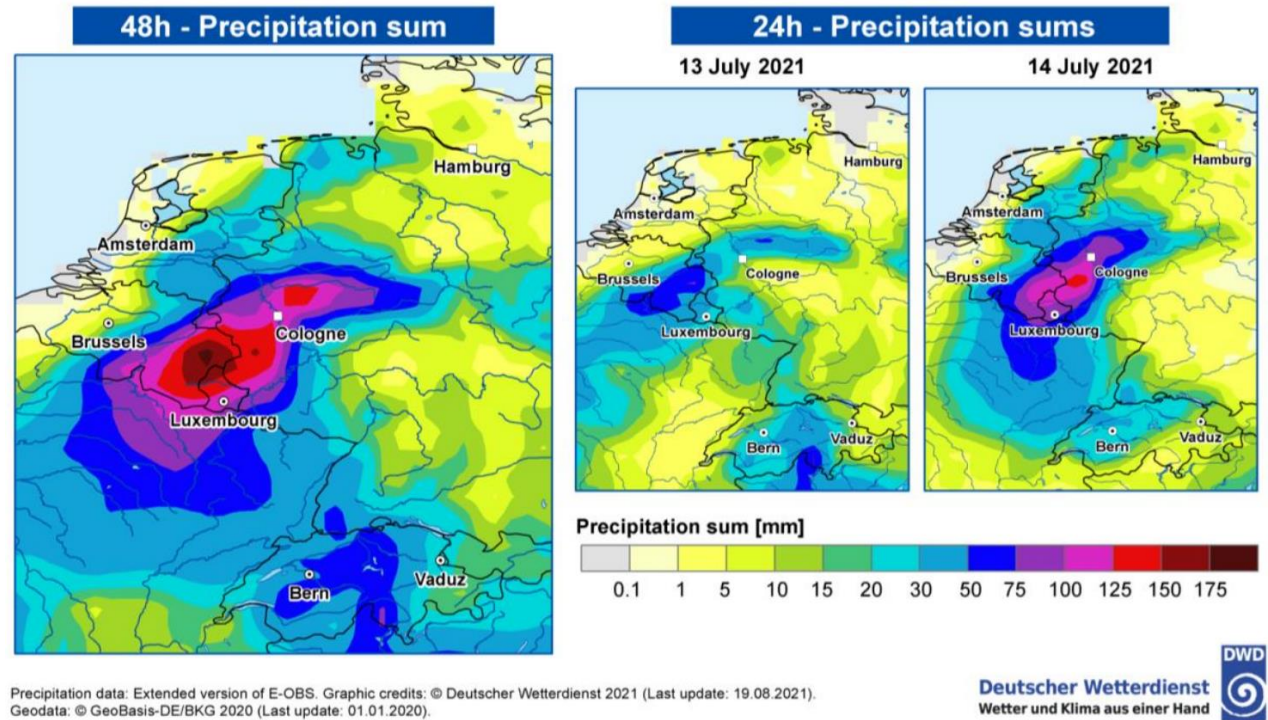


# **Description of 2021 flood event**

# Flood event 2021



Kreienkamp, F., Y.S., P., Tradowsky, J., Kew, S., Lorenz, P., Arrighi, J., . . . Wander, N. (2021). Rapid attribution of heavy rainfall events leading to the severe flooding in Western Europe during July 2021. *World Weather Attribution*, 2021, 1–51.



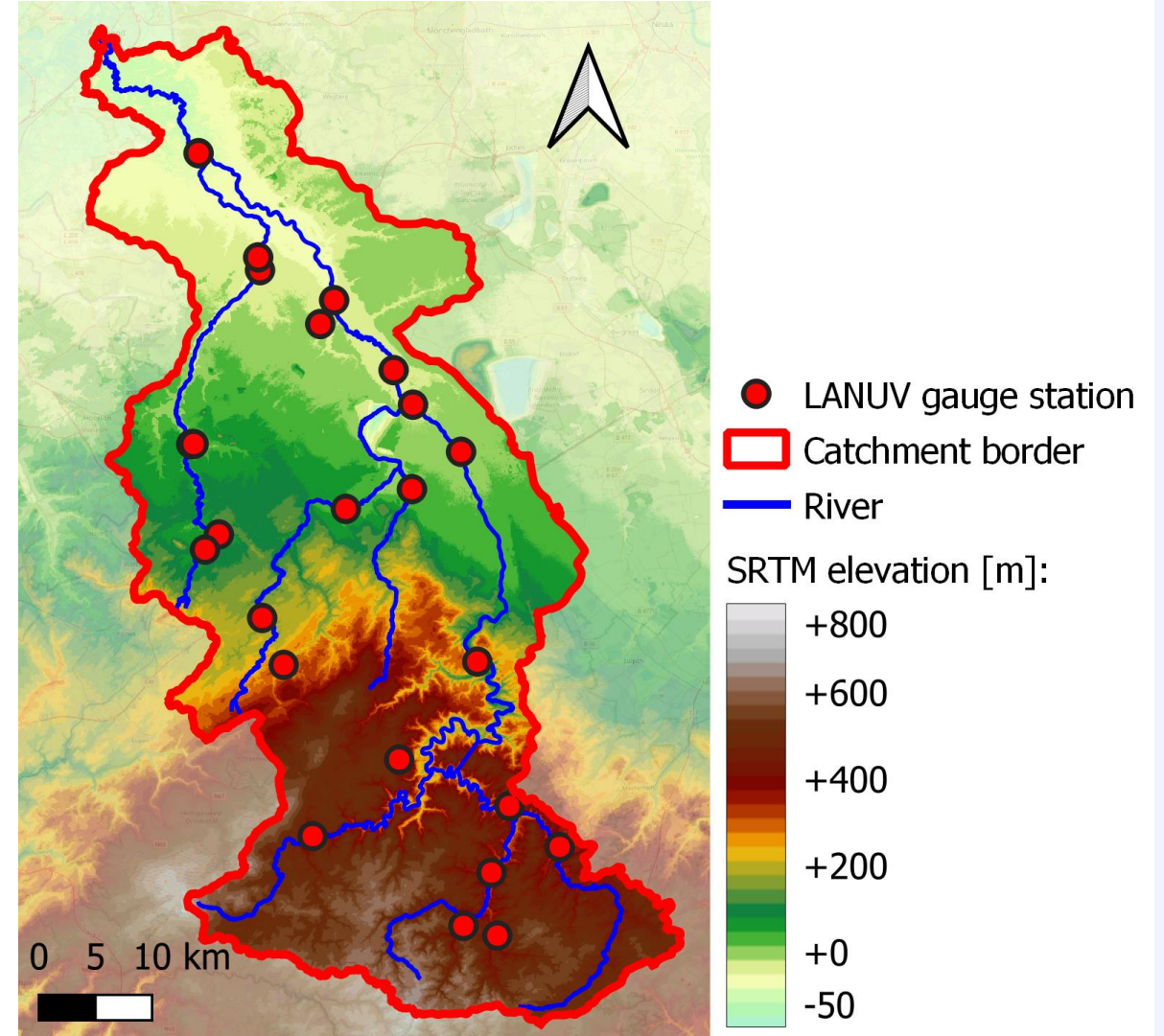
Precipitation data: Extended version of E-OBS. Graphic credits: © Deutscher Wetterdienst 2021 (Last update: 19.08.2021).  
Geodata: © GeoBasis-DE/BKG 2020 (Last update: 01.01.2020).

CEDIM Forensic Disaster Analysis (FDA) Group, Schäfer, A., Mühr, B., Daniell, J., Ehret, U., Ehmele, F., . . . Kunz, M. (2021). *Hochwasser mitteleuropa, juli 2021 (deutschland): 21. juli 2021 – bericht nr. 1 "nordrhein-westfalen & rheinland-pfalz"* (Tech. Rep.). Karlsruher Institut für Technologie (KIT). doi:10.54445/IR/1000135730

# Flood event 2021

## Examples of impact on Rur catchment

- Pluvial flooding in steep Eifel (Gemünd)
- Rapid filling of reservoirs (Urft)
- Inde river bursts into open pit mine
- Fluvial flooding of lower Rur river (Linnich)

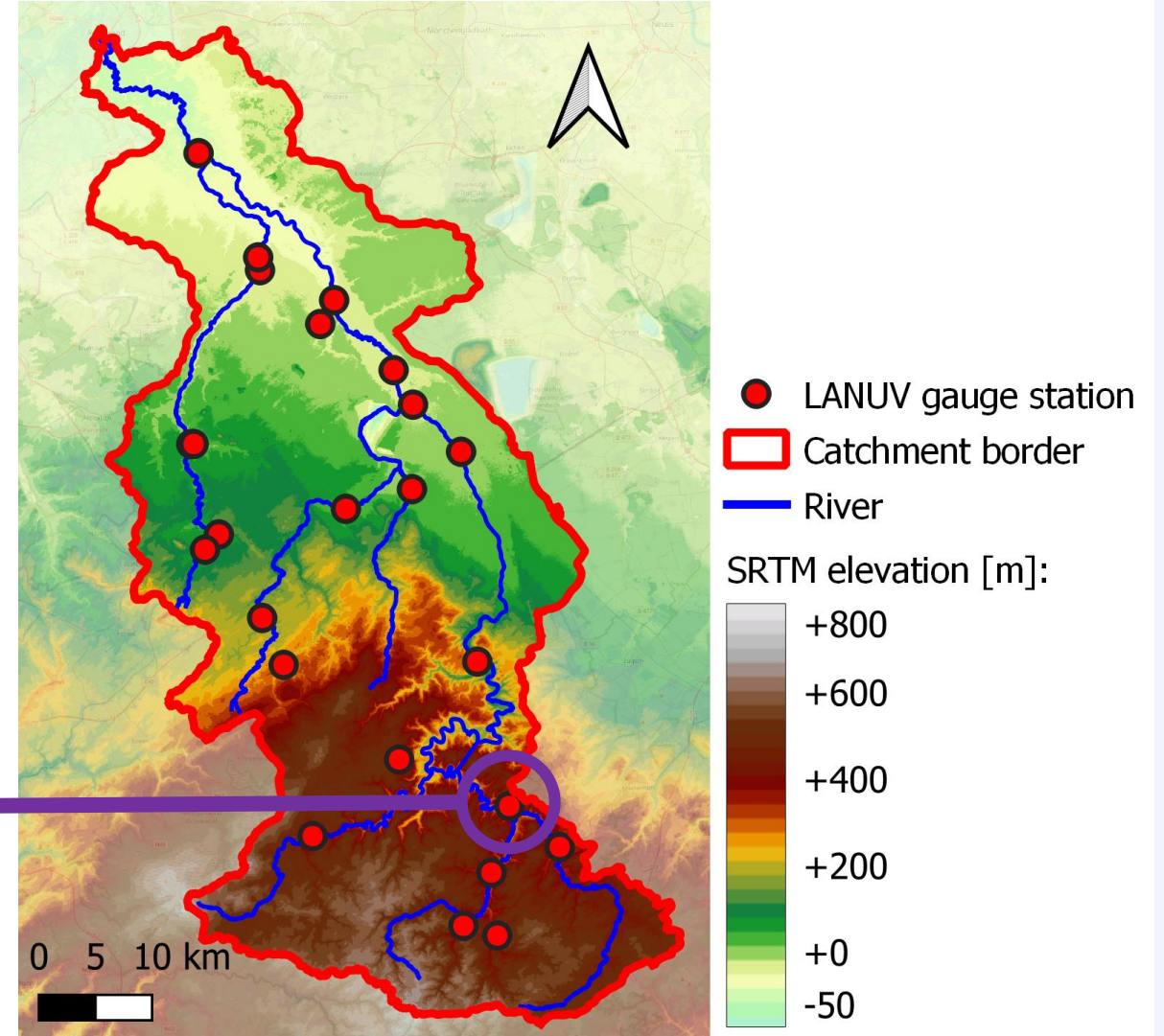




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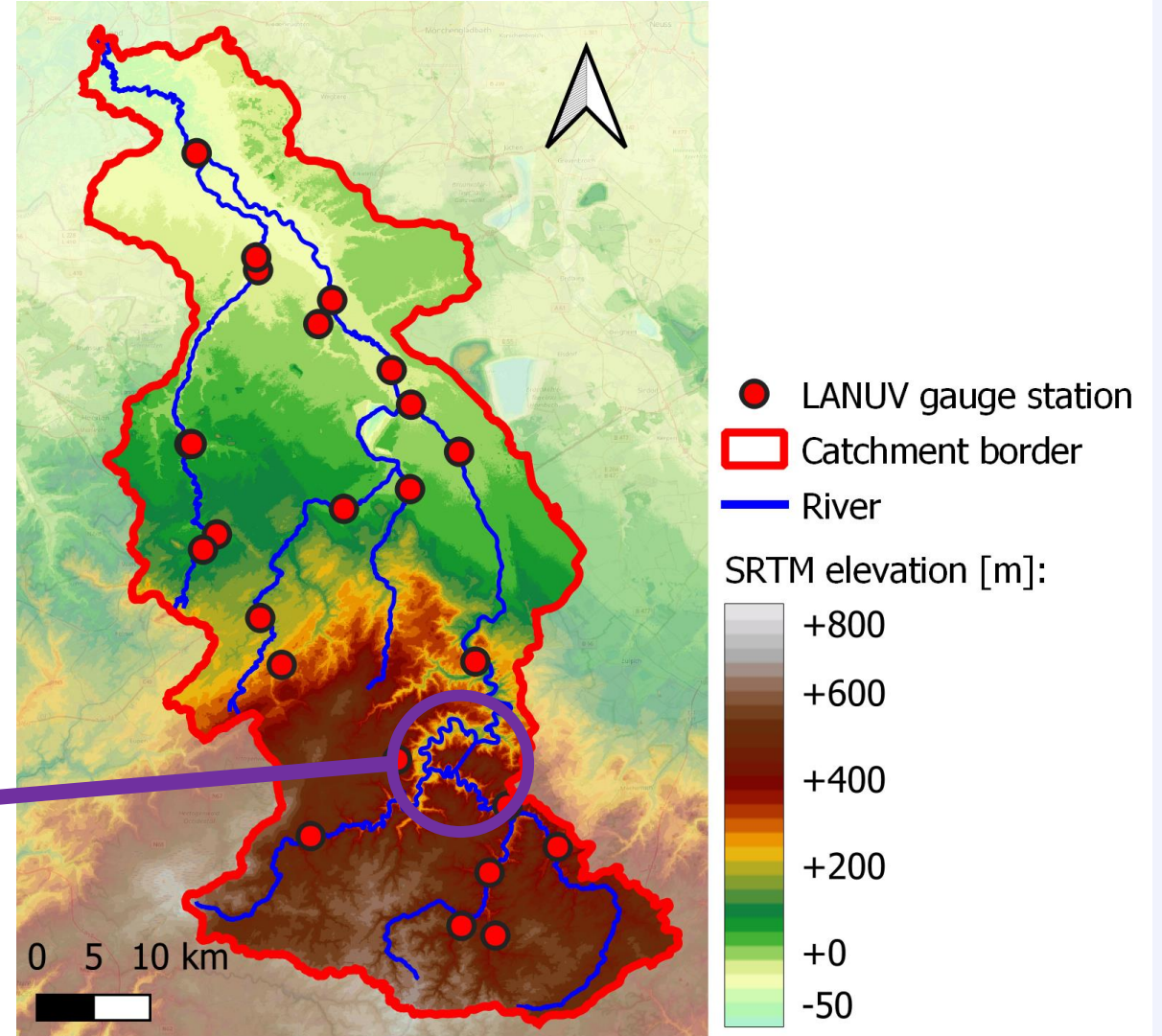
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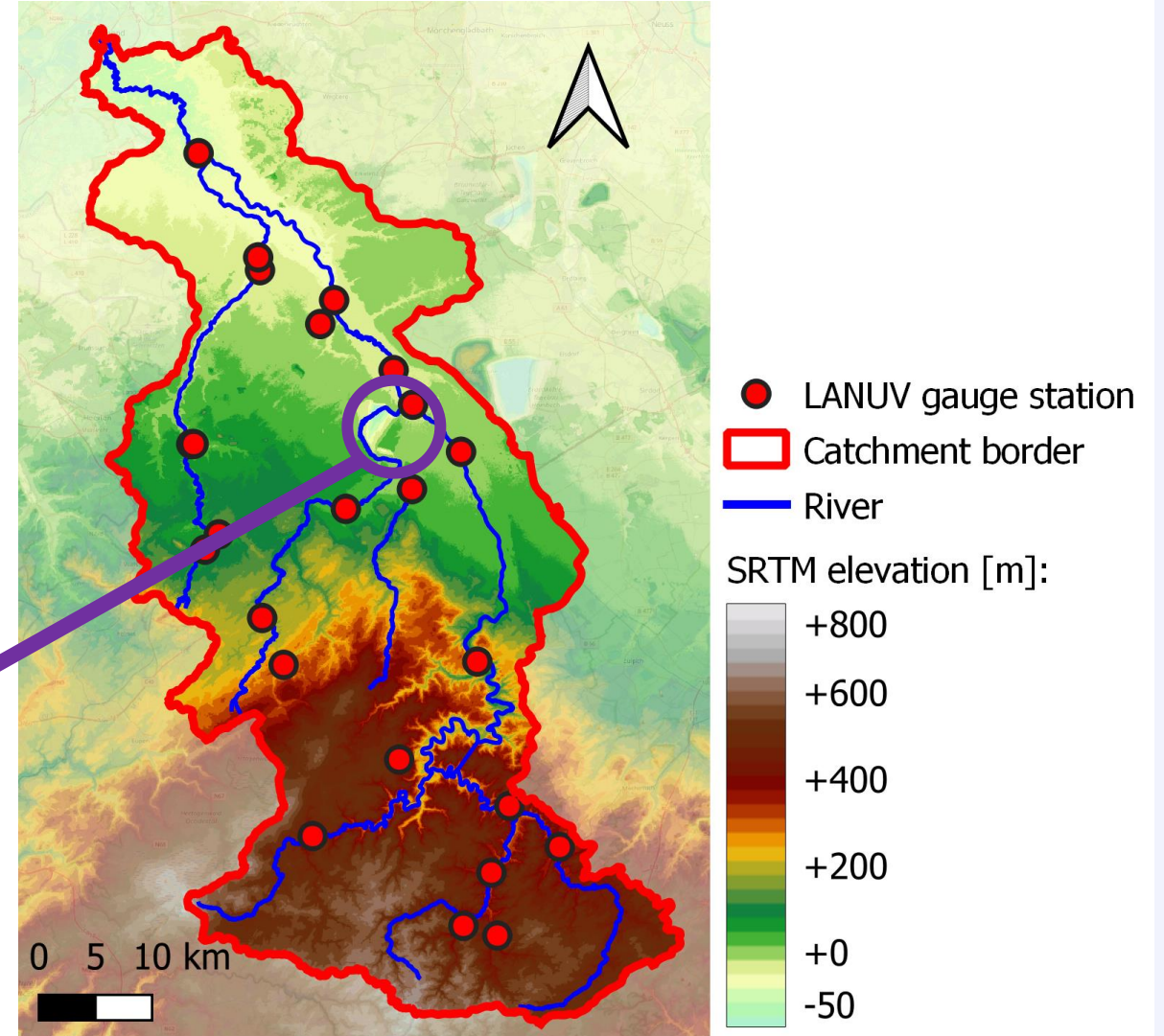




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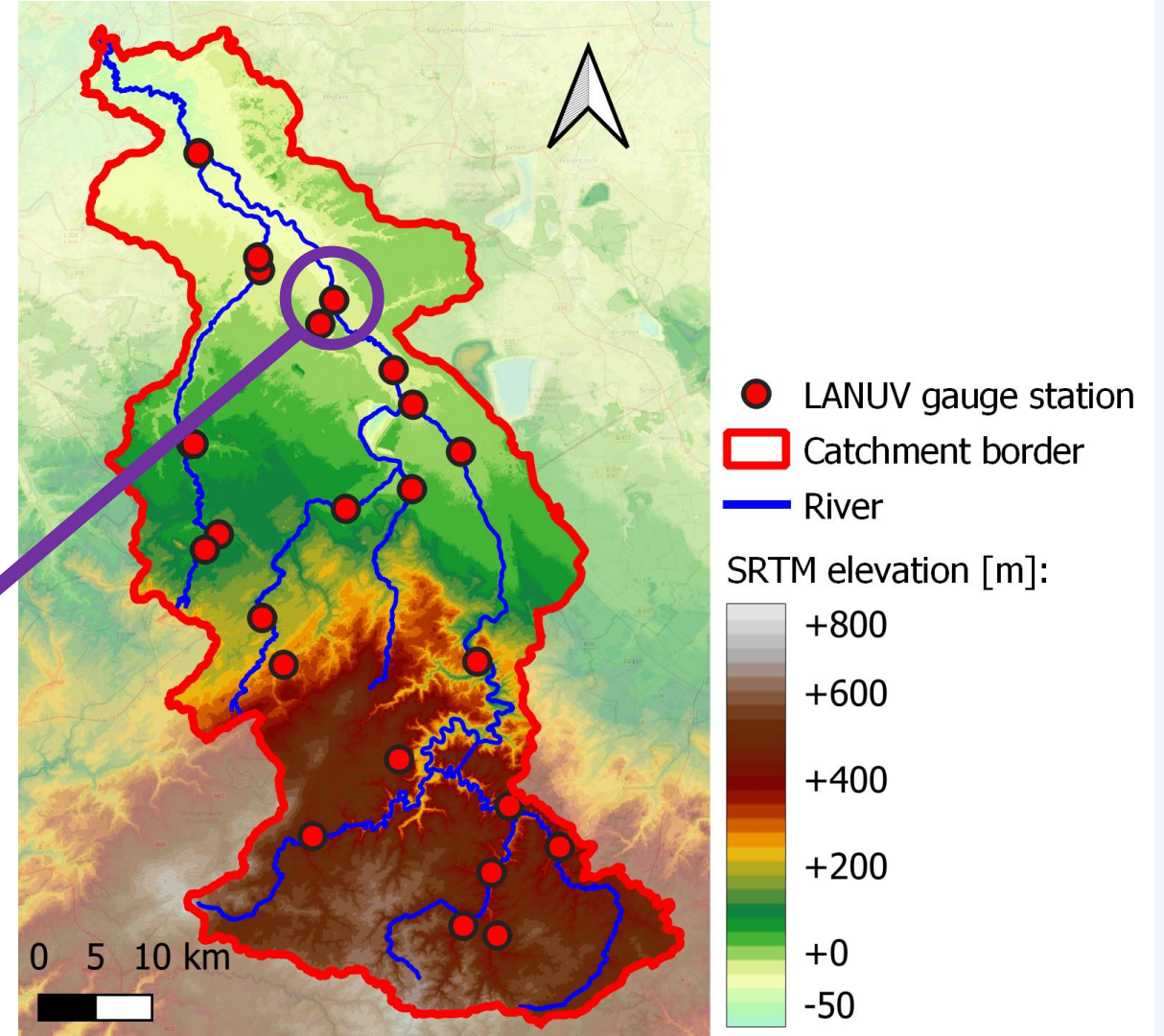




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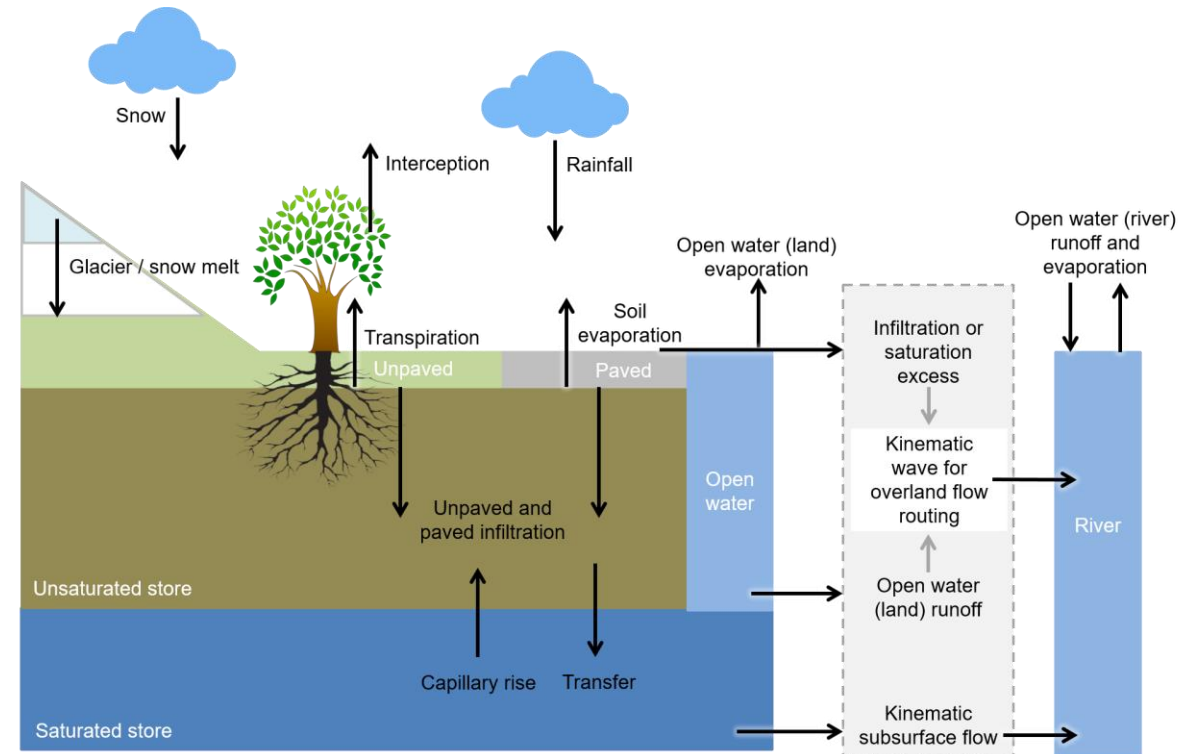


# Hydrologic and hydrodynamic modelling

# Hydrological modelling

Hydrological processes are modelled using **Wflow\_SBM**

- Distributed hydrological model of the entire catchment
- Vertical processes mainly based on Topog\_SBM
- Lateral processes: land runoff, river flow and subsurface flow (not a groundwater model)





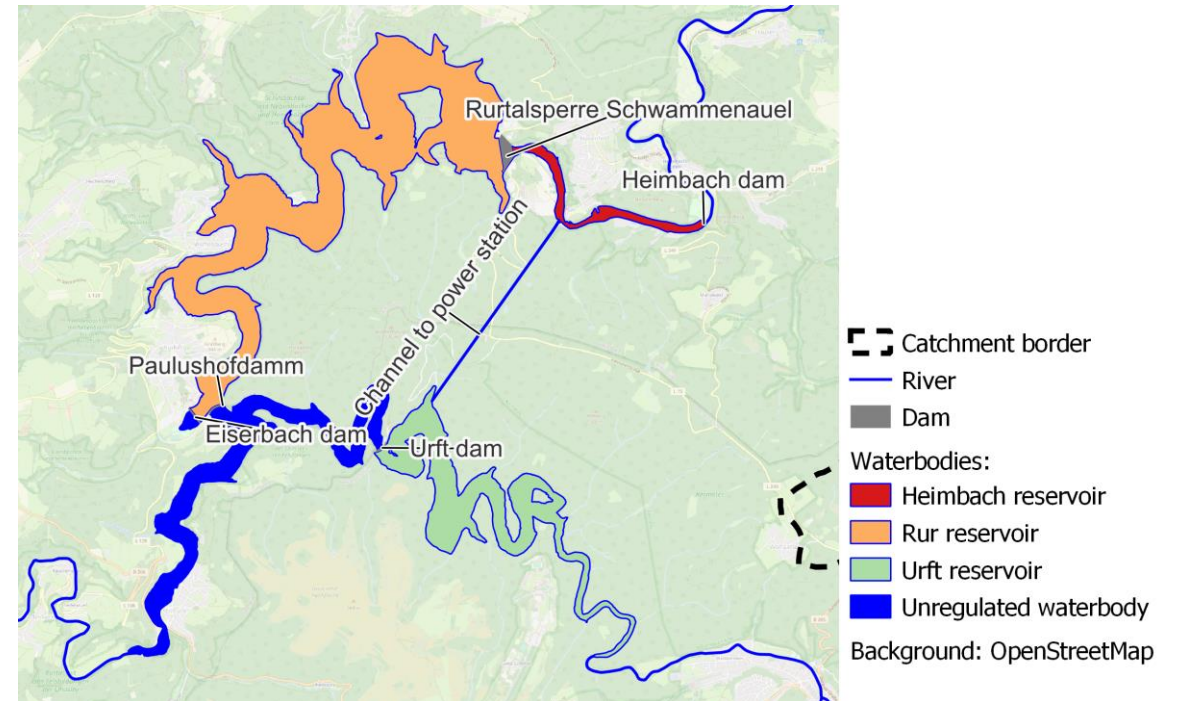
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Relevant for Rur catchment:

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# Hydrological modelling

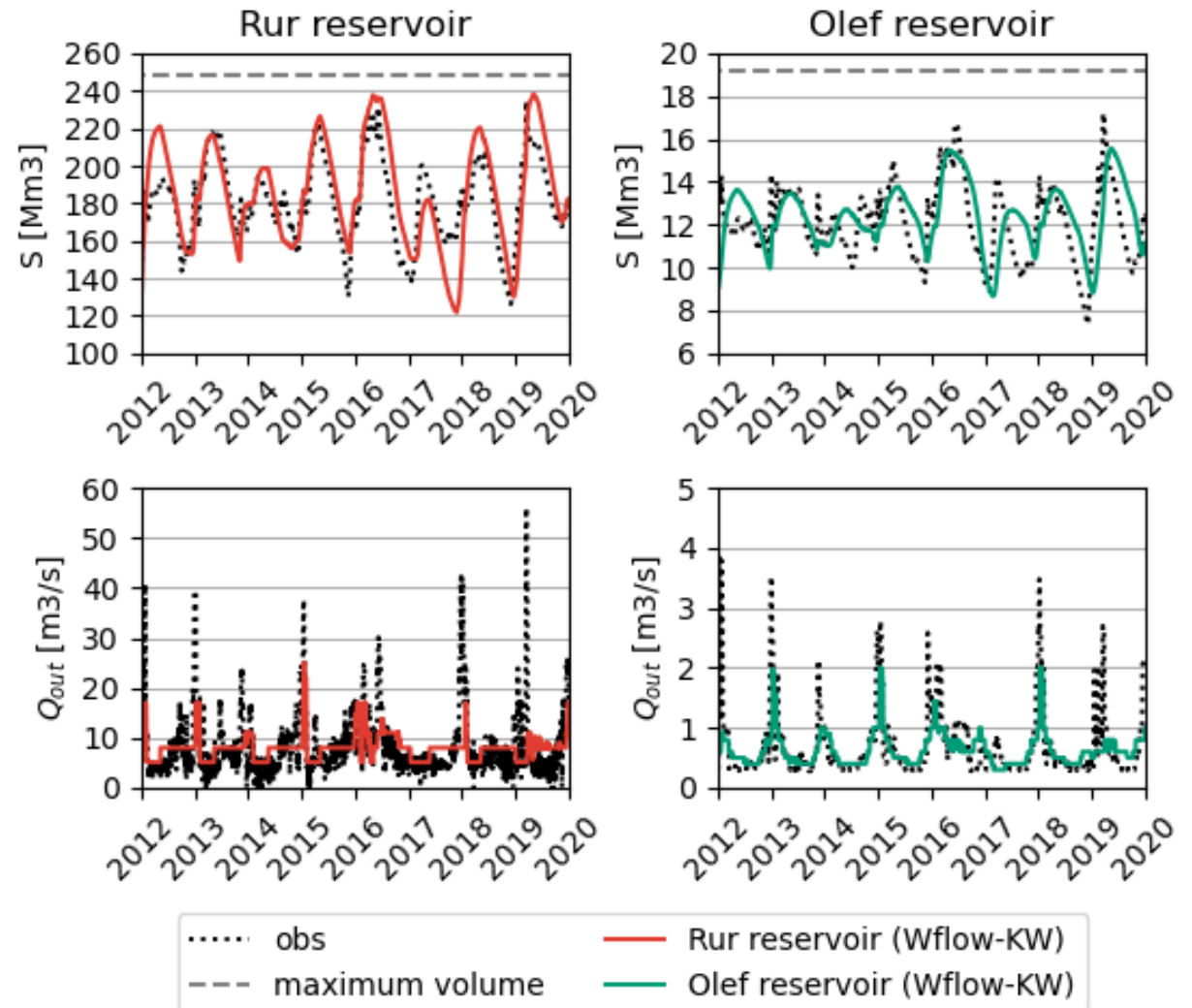
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Reservoir with volume-based operations rules (E-OBS 2012-2020)



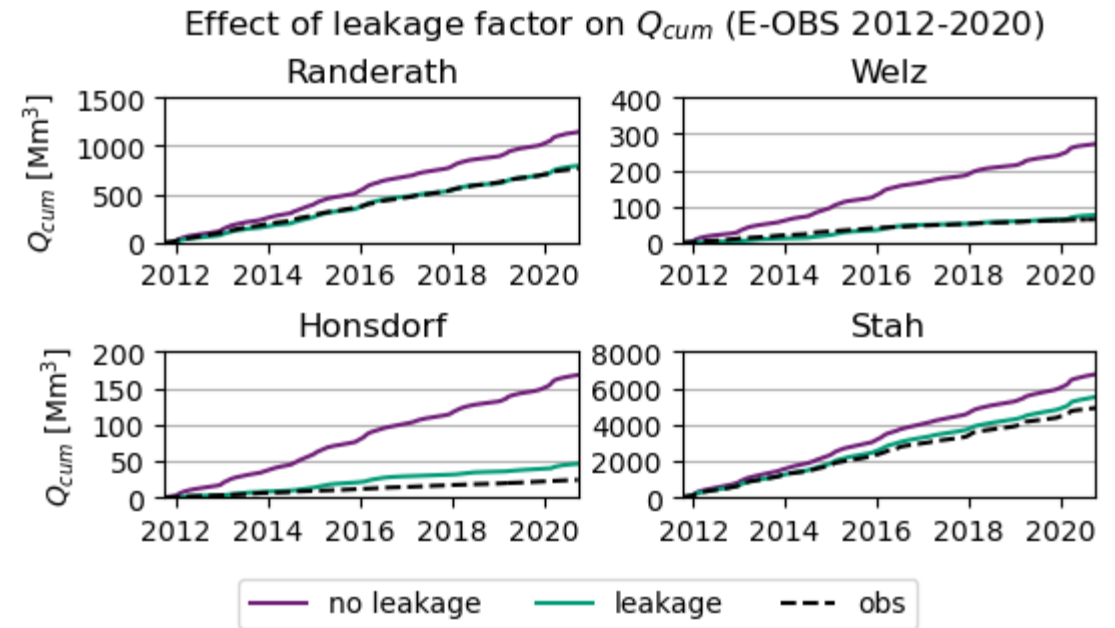
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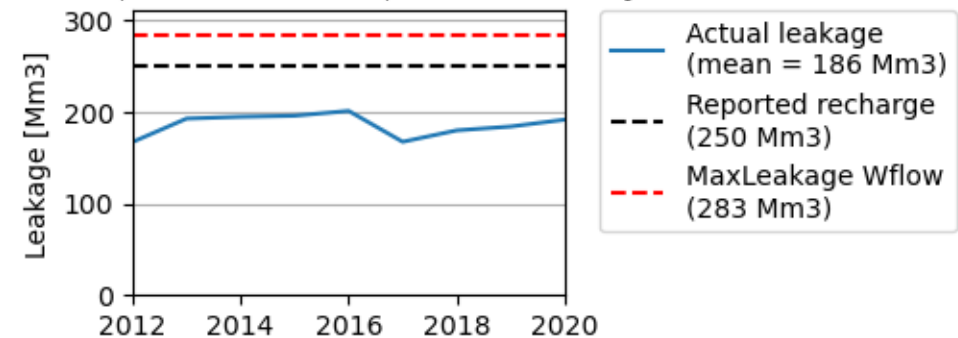
Relevant for Rur catchment:

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- **Water ‘loss’ modelled by leakage term**



Annual total leakage (E-OBS 2012-2020)

$L_{max,1} = 0.4$  and  $L_{max,2} = 0.8$  mm/day

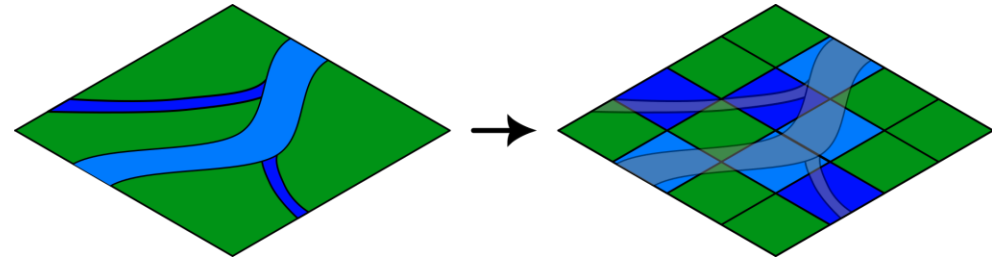




# Hydrodynamic modelling

## Wflow\_SBM (500 m x 1000 m)

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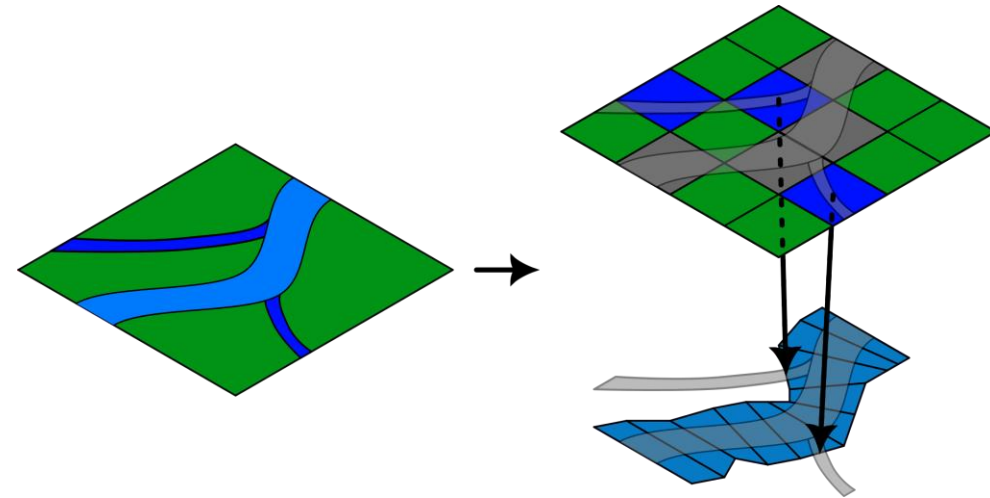
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ProMaIDES (impact-based modelling)

- **1D river model of Rur with 755 profiles**
- 2D floodplain grids (5 m x 5 m)
- Stand-alone 1D model (PM-1D) or coupled 1D-2D model (PM-2D)



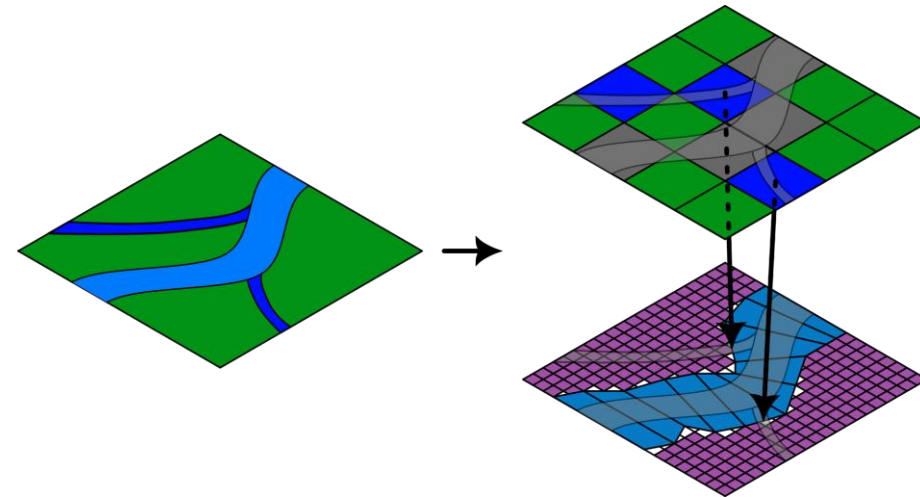
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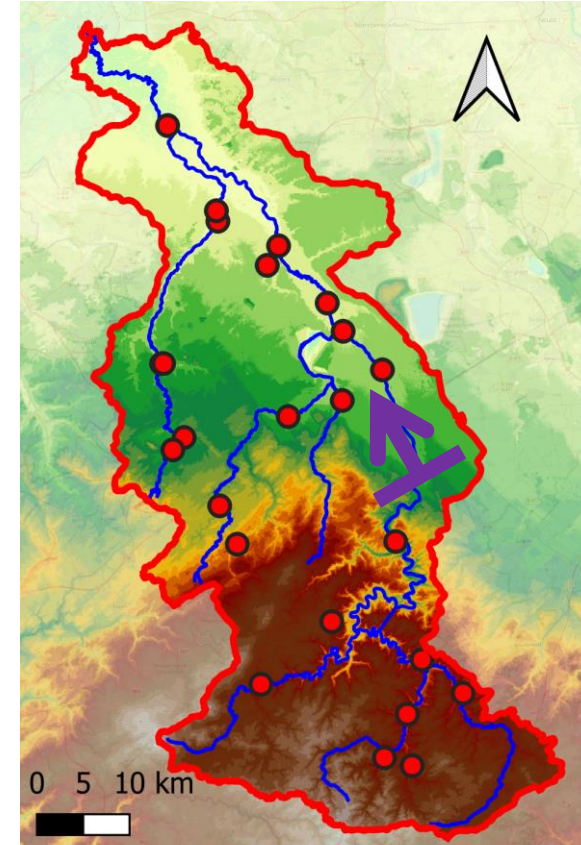
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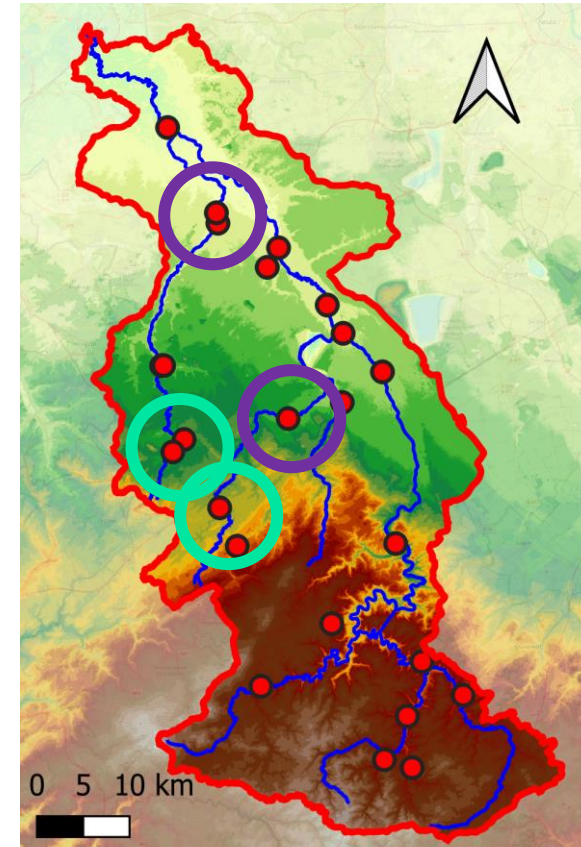
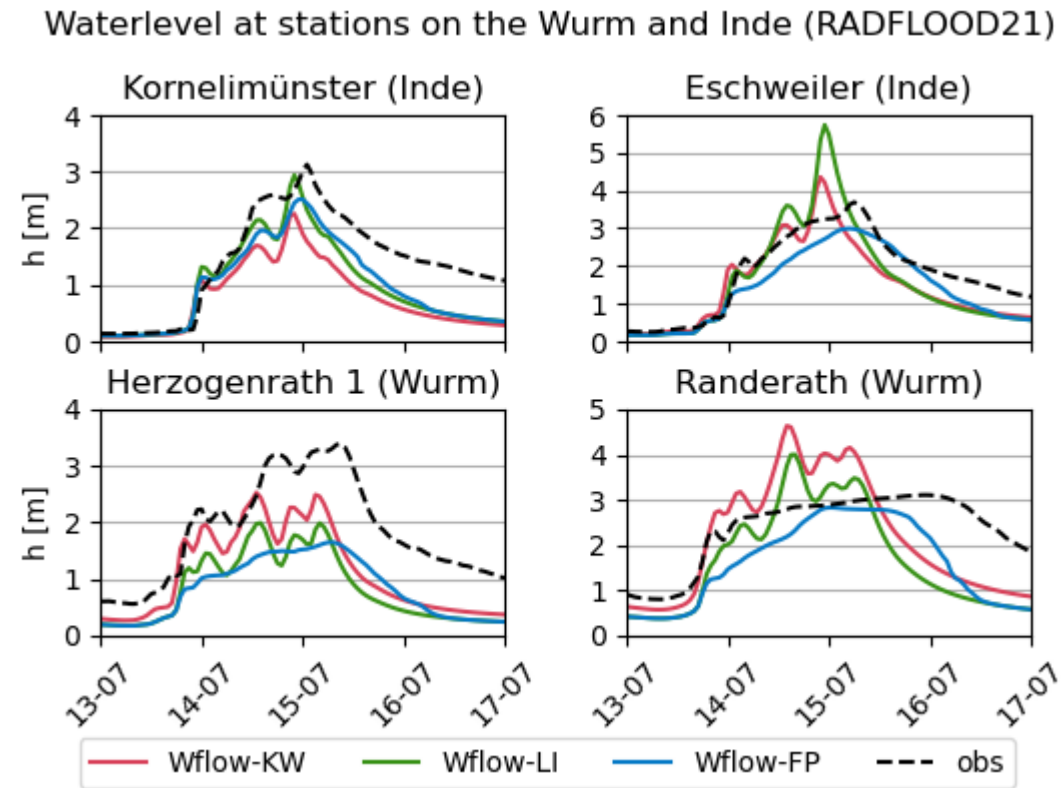
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- **From Heimbach dam to Roermond**





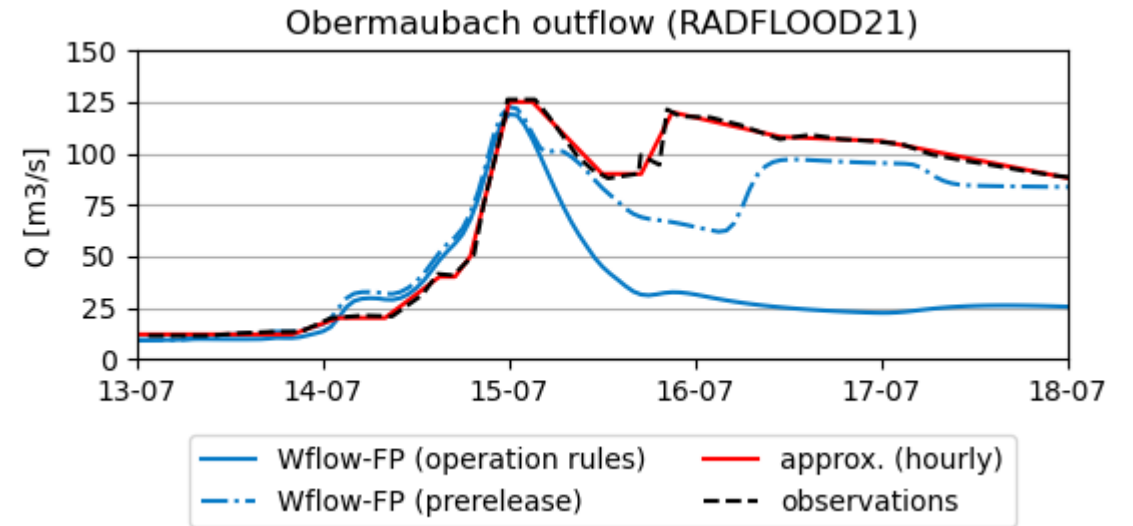
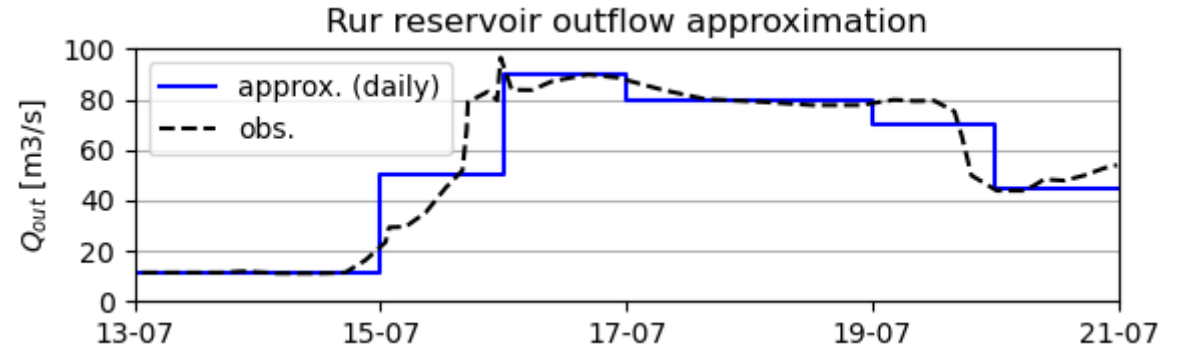
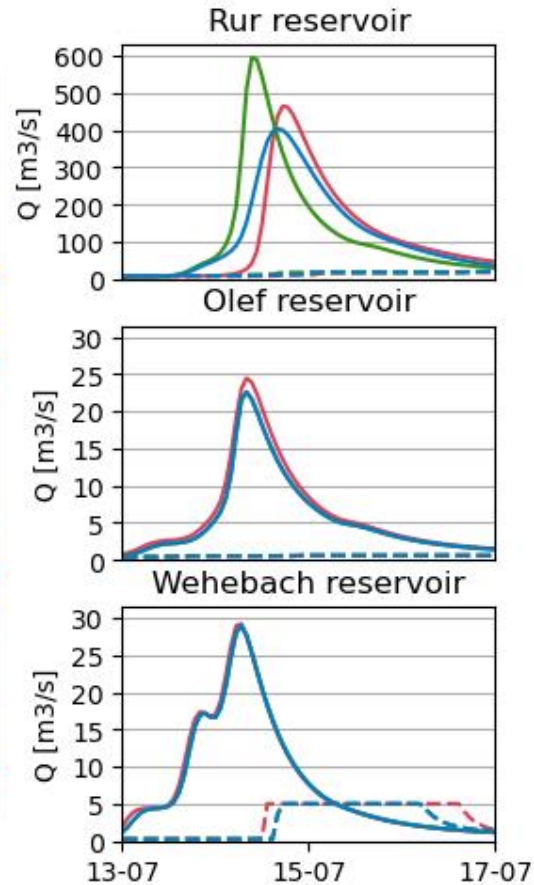
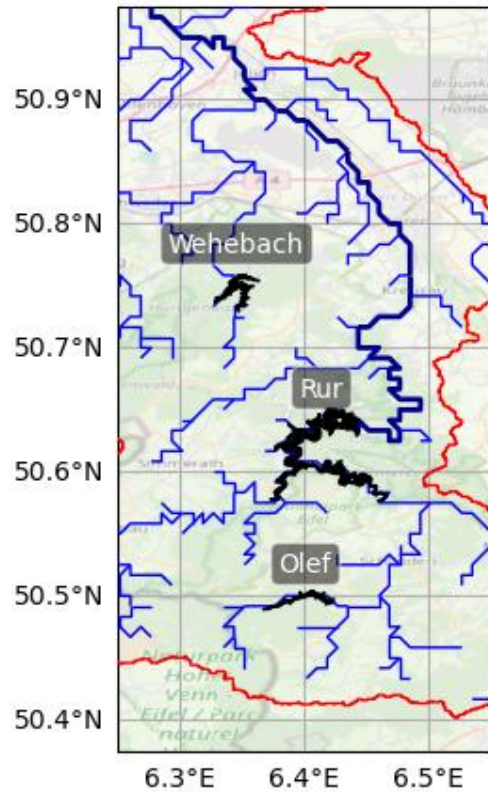
# Results: the 2021 flood event

# How are the tributary inflows modelled?



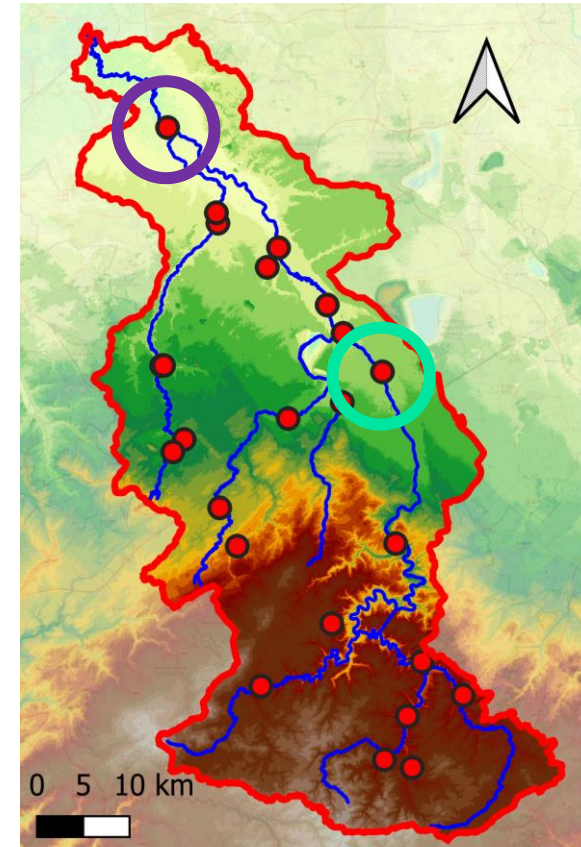
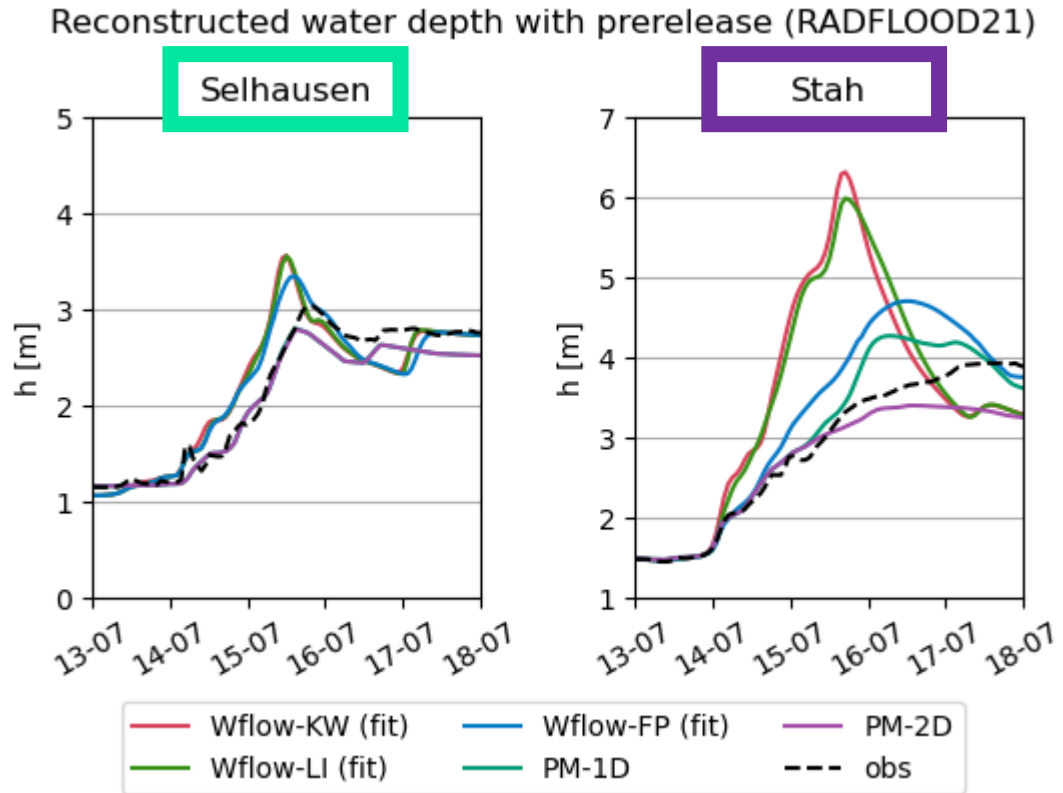
# How is the reservoir simulated?

Reservoir inflow and outflow (RADFLOOD21)



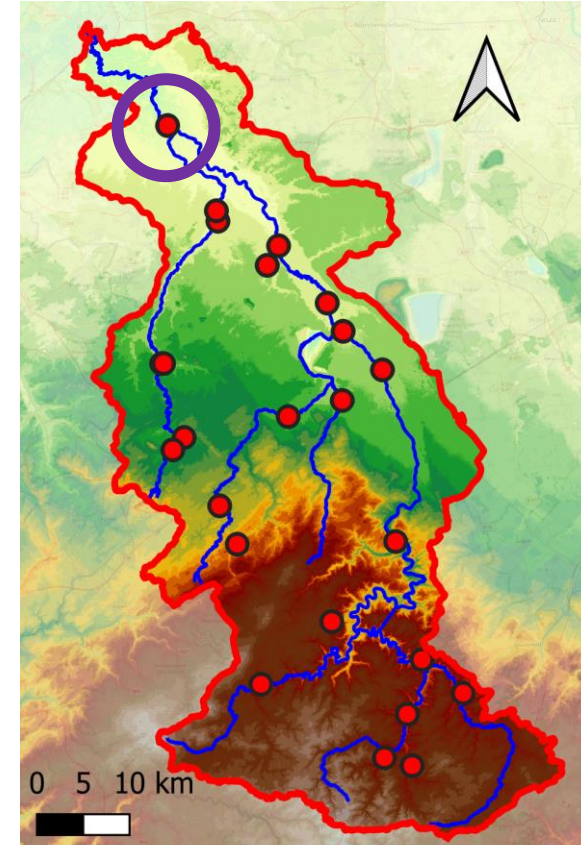
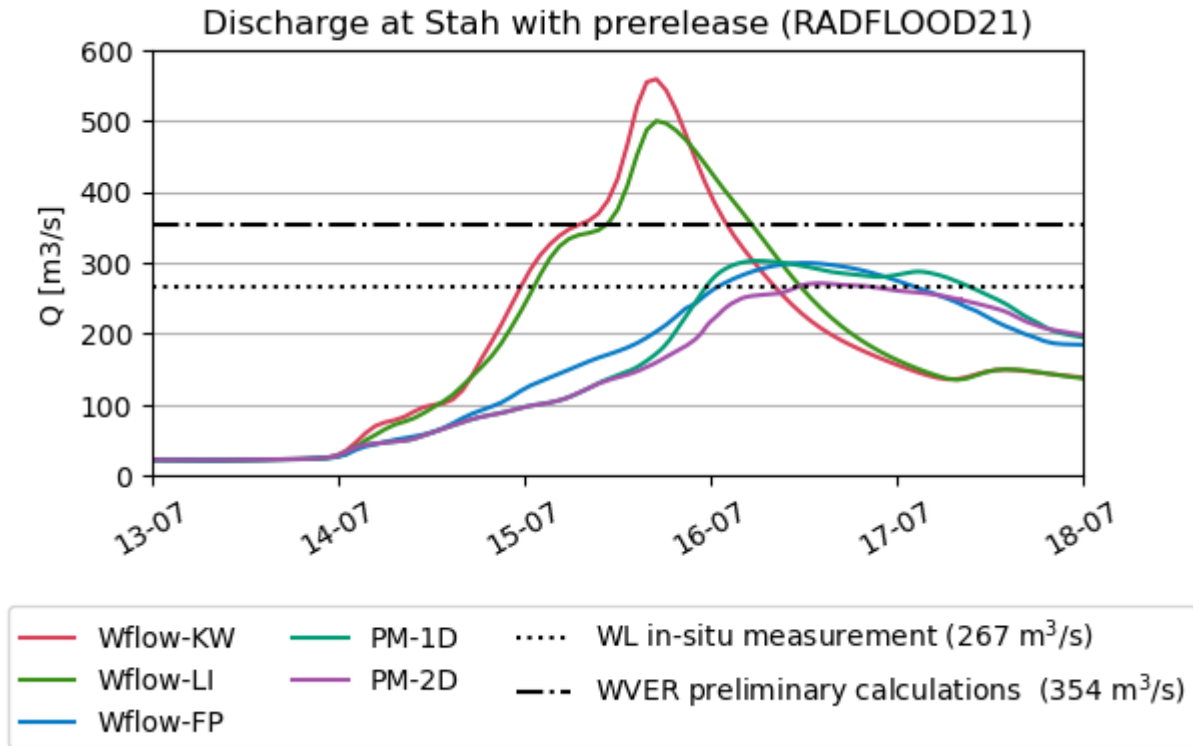
Based on preliminary results from WVER presentation  
*Extremes Hochwasser 2021 Bürgerinformation (18-11-2021)*

# Results: water depths at Selhausen and Stah



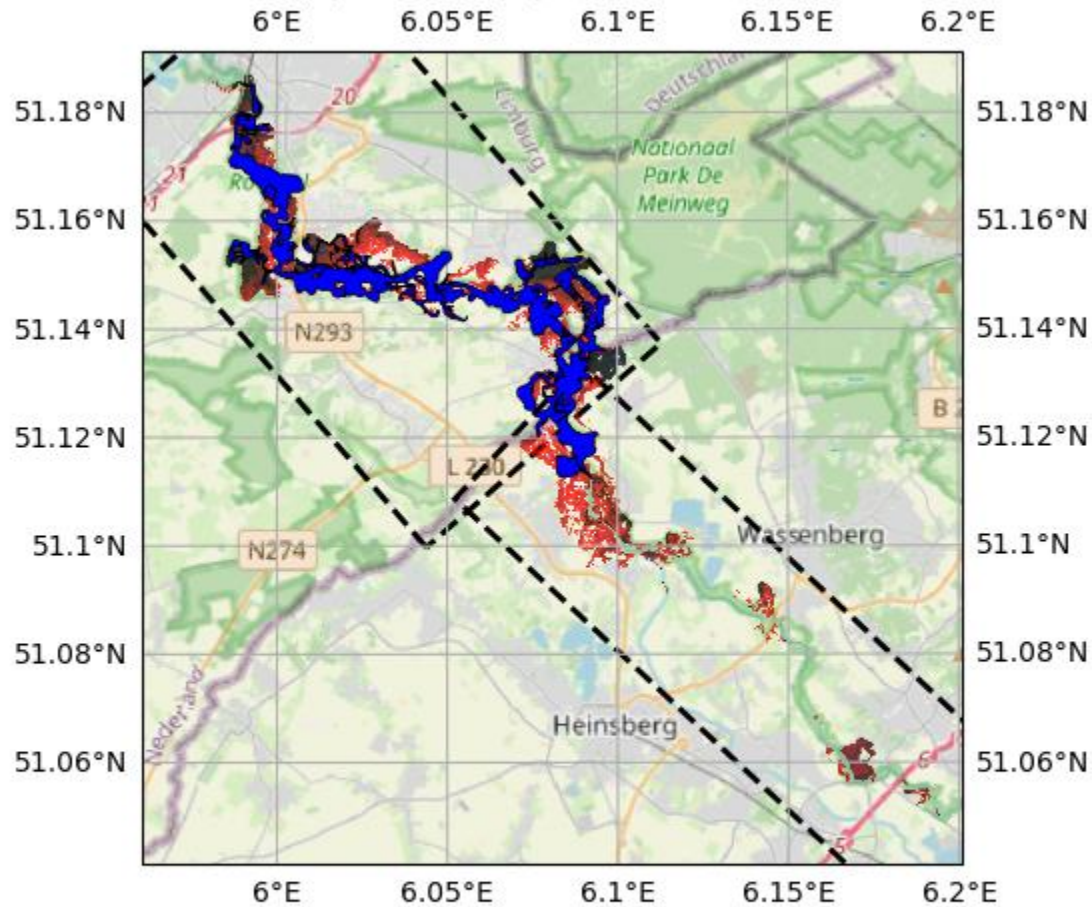


# Results: discharge at Stah

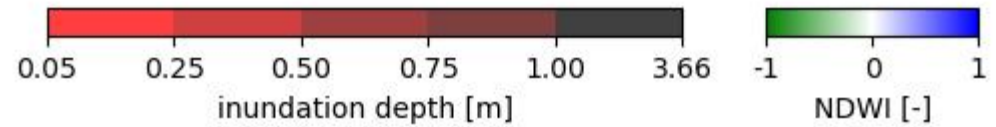
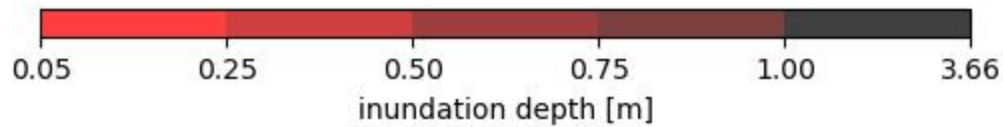
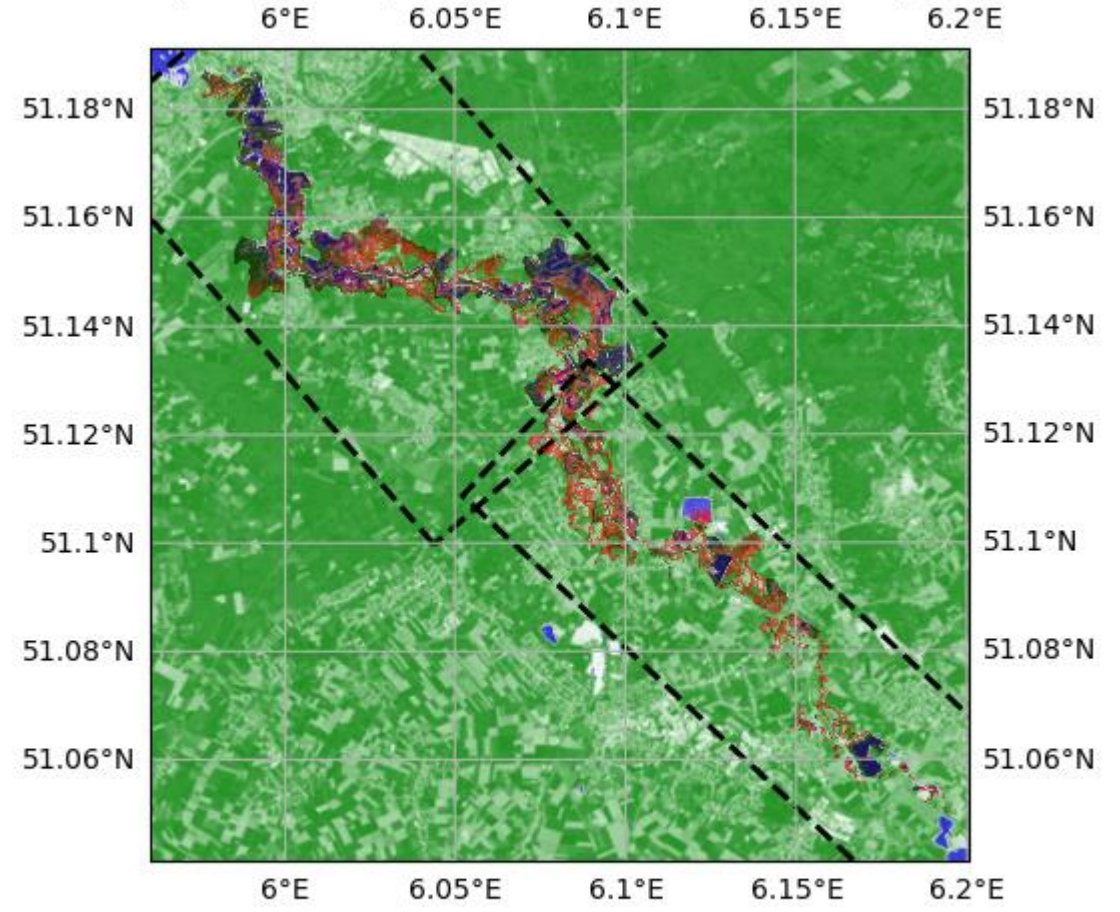


# Results: Validation using flood extent

Flood extent map (11-03-2019) and PM-2D maximum inundation



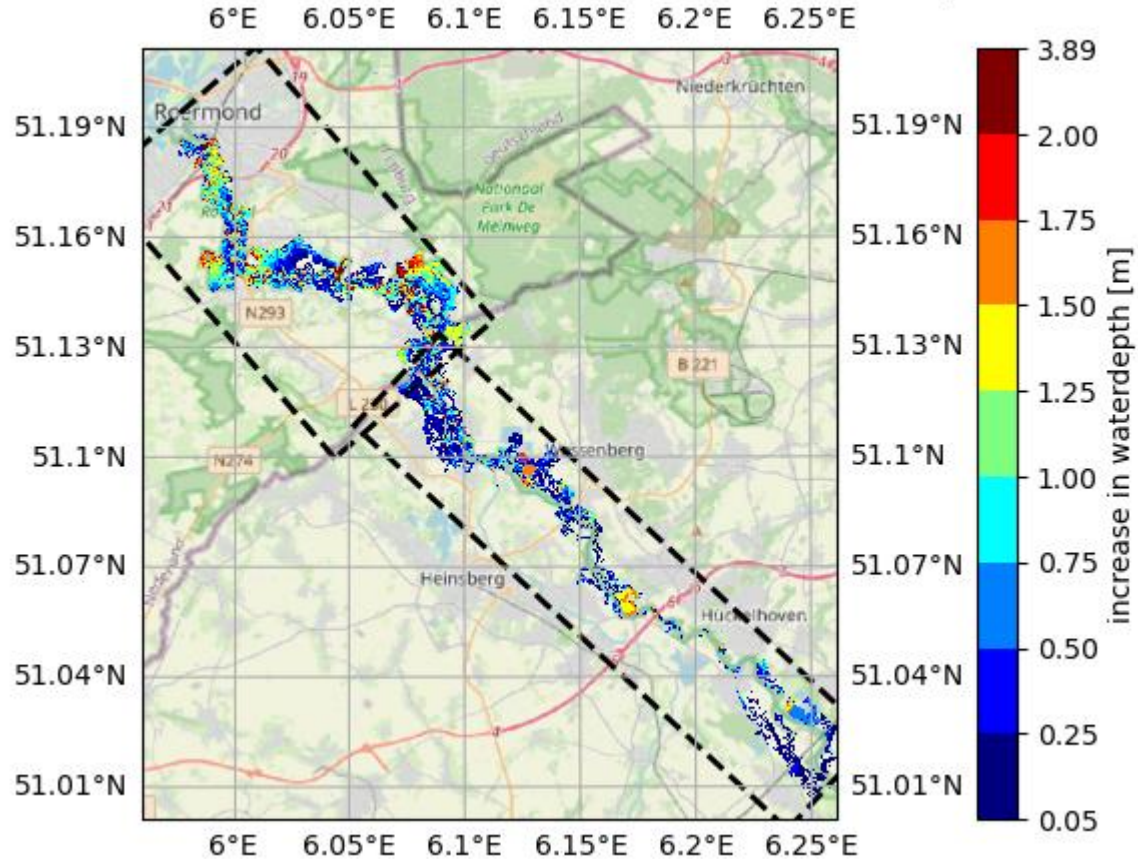
Landsat 8-9 (18-07-2021) with PM-2D inundation overlay (17-07-2021)



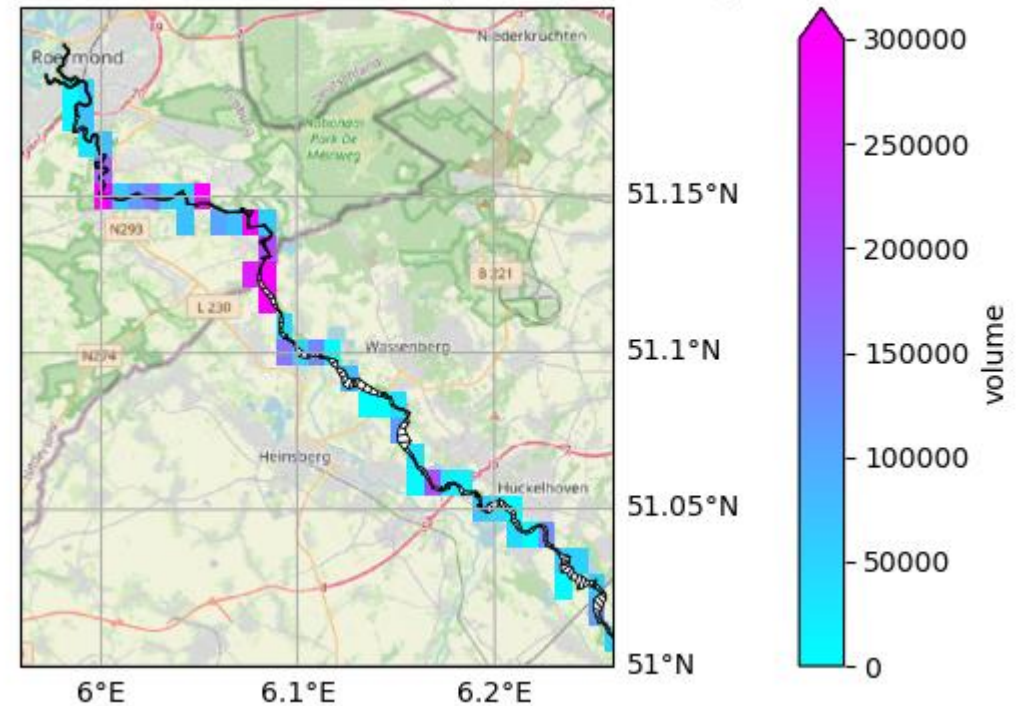


# Where does floodplain attenuation take place?

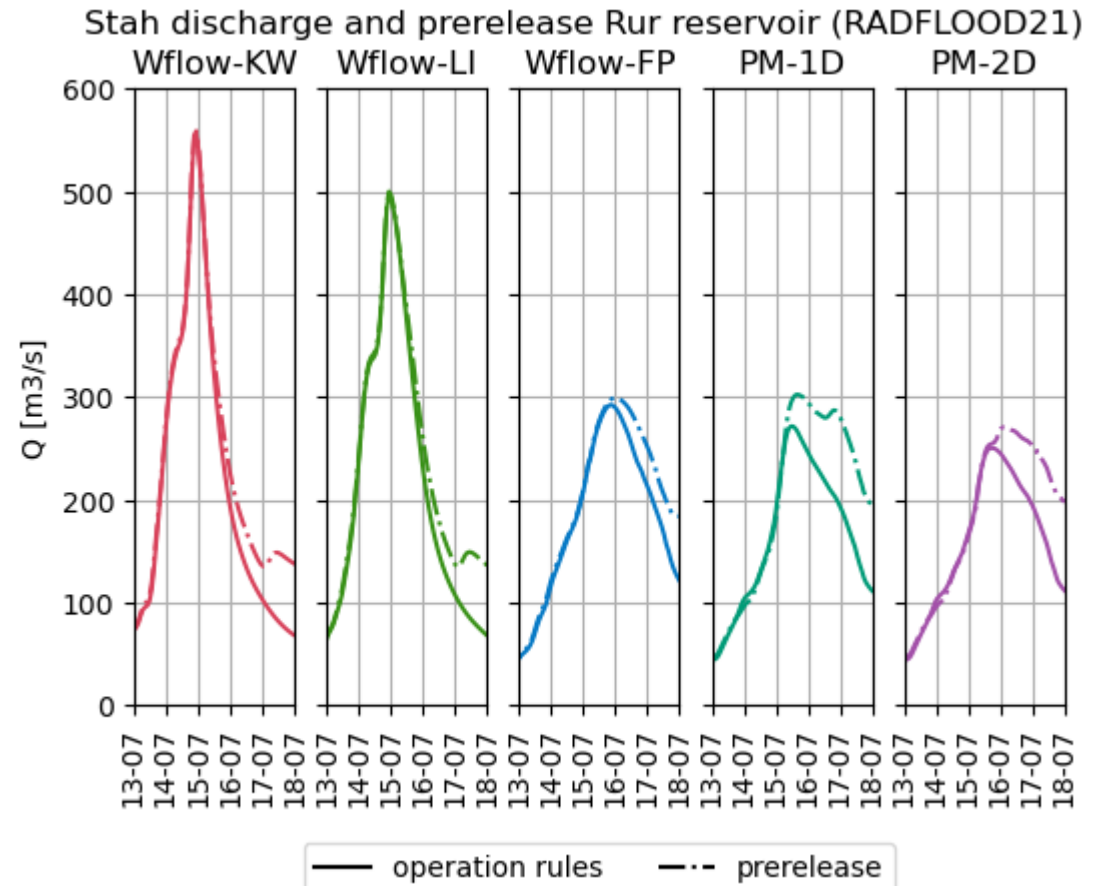
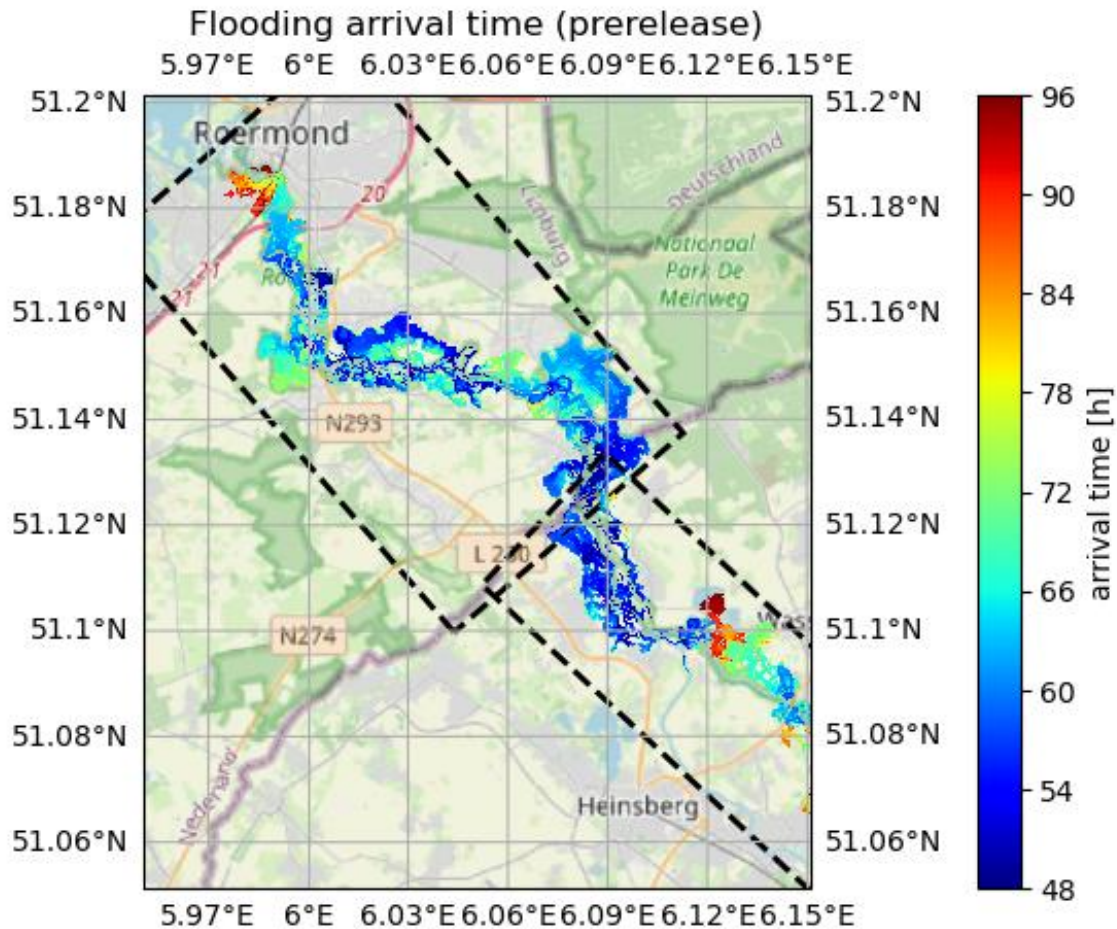
Inundation downstream of Stah (PM-2D with prerelease)



Maximum volume stored in floodplains (Wflow-FP)



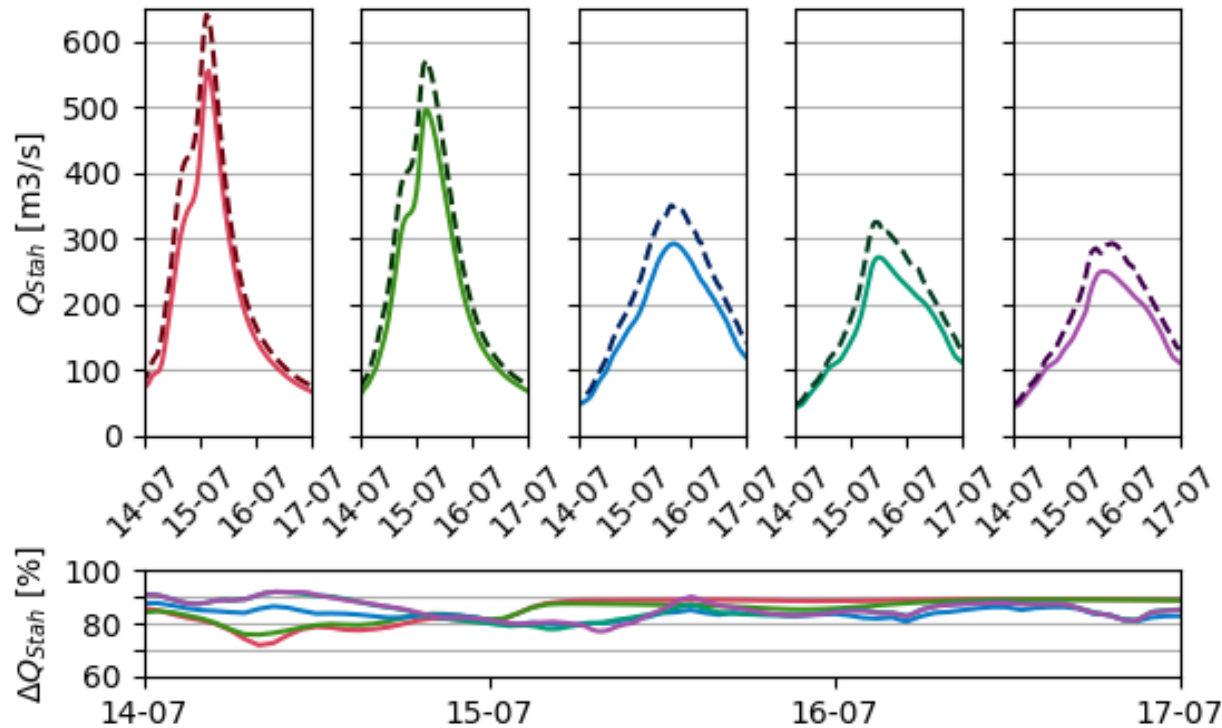
# How significant is the additional prerelease?



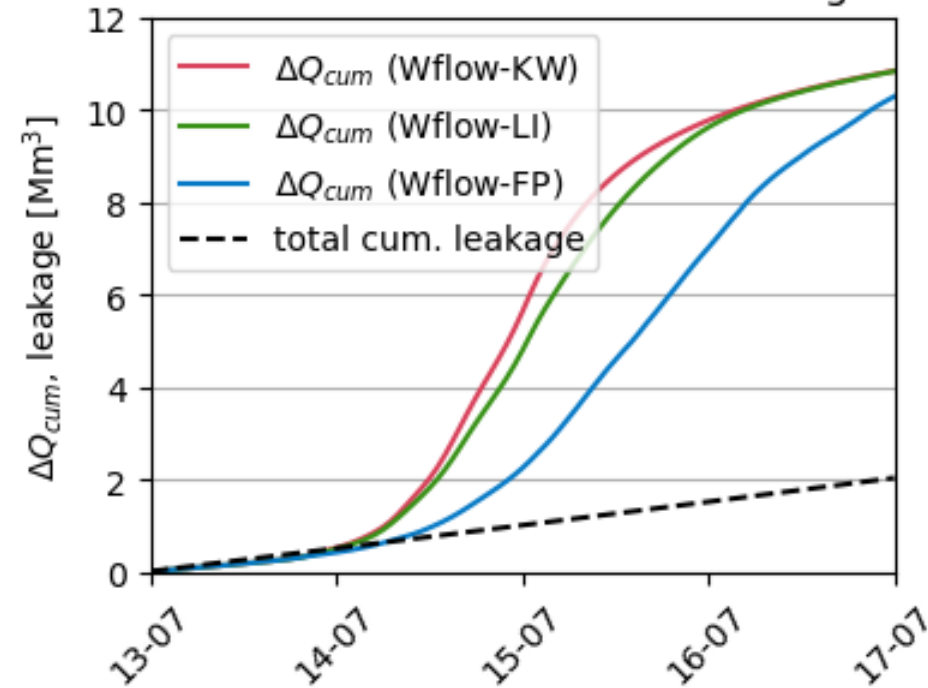


# What is the effect of the leakage parameter?

Discharge at Stah with leakage (-) and without leakage (--)

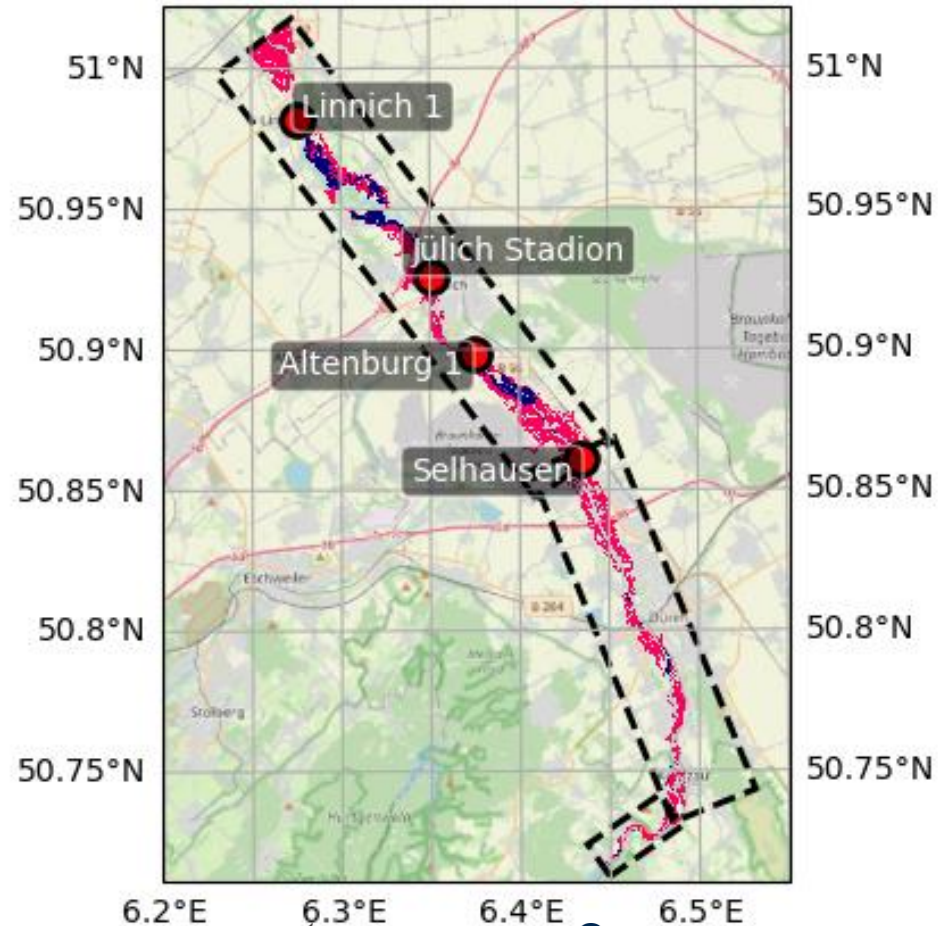


Difference in cum. discharge at Stah per model and total cum. catchment leakage

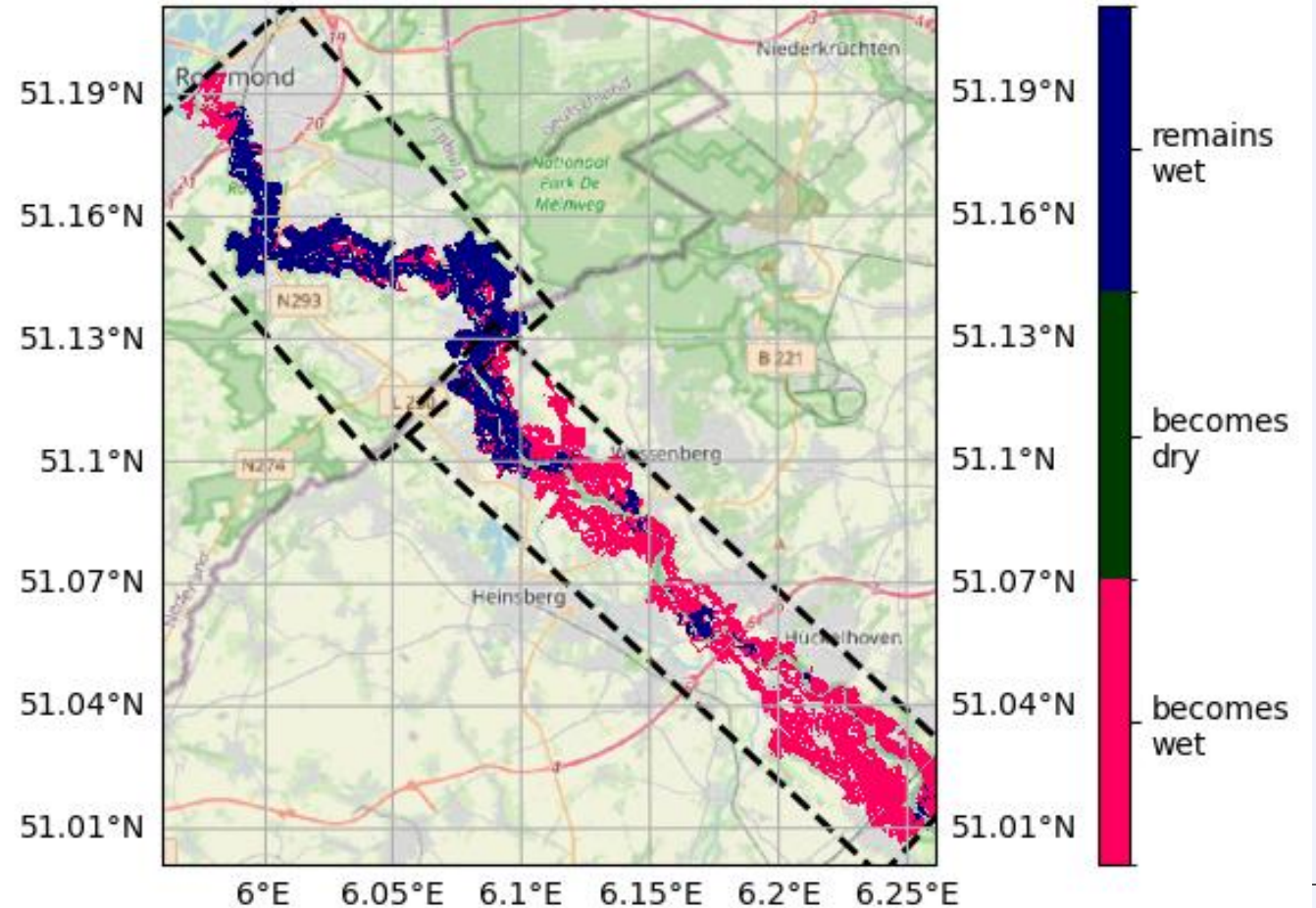


# Hypothetical: What if there were no reservoirs?

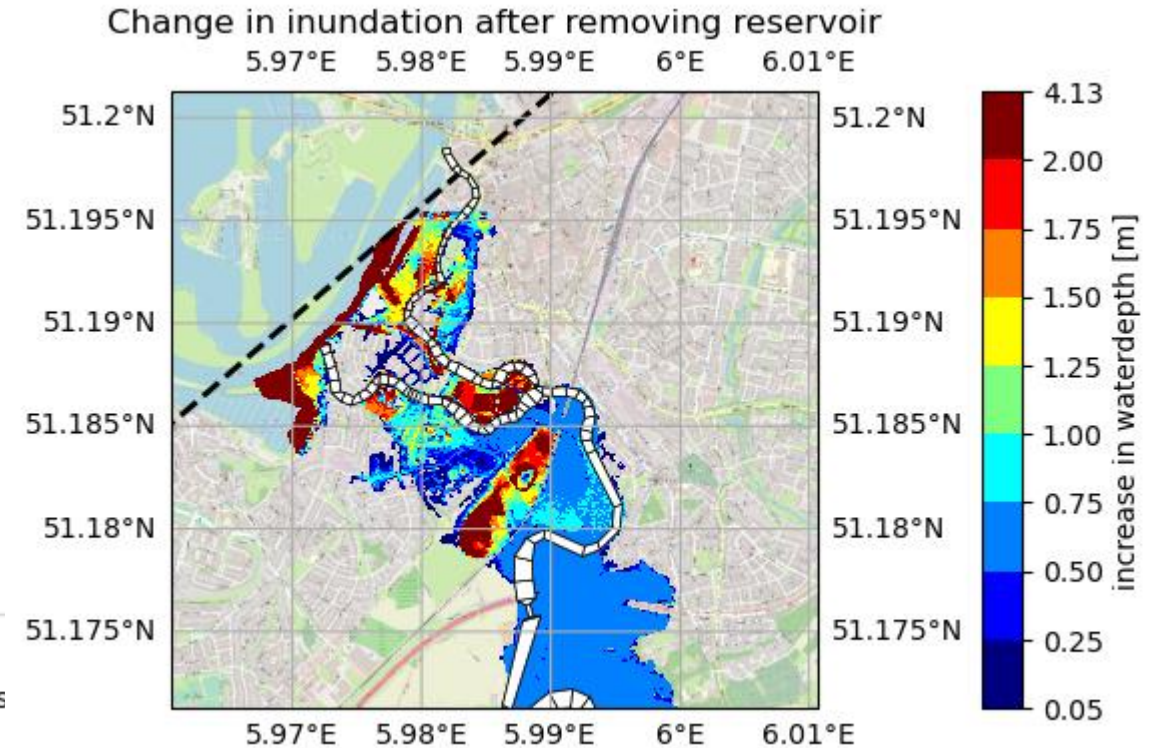
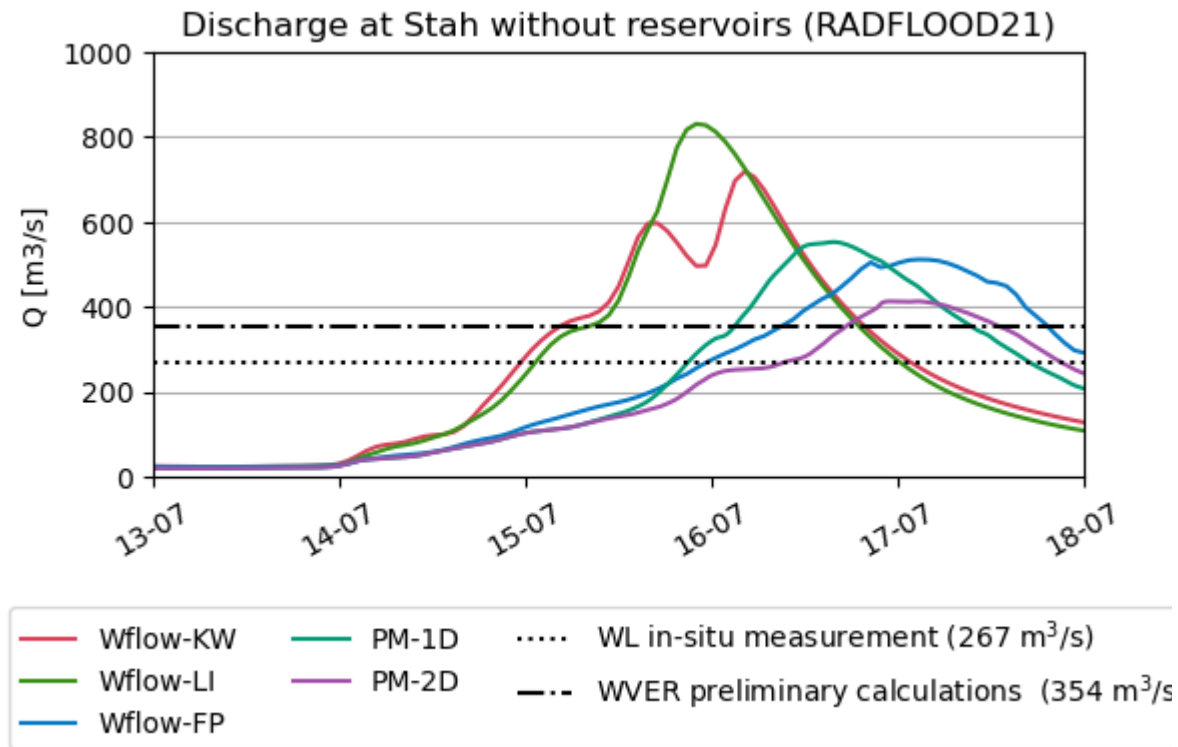
Change in wetted areas after removing reservoir



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# Final remarks

Several factor important for modelling the 2021 floods for the Rur river:

- Floodplain attenuation, reservoir modelling and leakage factor
- Reservoir prerelease is important to include in hindcast → also operational forecast model

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- Detailed inundation maps and water depths in Roermond can only be quantified using a high-resolution 1D2D model (PM-2D)

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Further research

- The effect of leakage parameter is significant in the results, but there is no extensive academic literature on the effect of mining pits on flooding processes
  - Extend Wflow with a groundwater model to validate the effects of the leakage parameter
  - Consider the effects related to flood safety when the lignite mine closes



# Thank you for your attention!

Questions? Ask away!

Interested in detailed results, thesis report/presentation or other projects?

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