Modelling of micro-pollutants in a strongly-regulated cross-border lowland catchment

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What is the problem?

- **Chemical substances (e.g. metals, fertilizers, pharmaceuticals, plastics) are detected in large quantities in rivers all over the world**

1. Around 150,000 substances are washed into the environment worldwide through the production of goods
2. In sewage treatment plants, many of these substances are not or not completely degraded and retained
3. Not all of these substances can be broken down by nature into harmless end products (e.g. via photolysis)

Daily Mail

Birth control hormone is making its way into streams and hindering fish's ability to reproduce

Biologists looking to see if those hormones affect fish exposed them to ... a lot of things, but they weren't designed to remove pharmaceuticals,' ...

vor 3 Wochen

New Scientist

Ban of vulture-killing drug in India is working

Ban of vulture-killing drug in India is working ... as a death of a Eurasian griffon vulture in Spain was recently attributed to a similar drug. Vulture ...

22.10.2014

Why model?

- Thousands of these substances can be detected analytically in the laboratory today
- **But:** Measurement data provides only temporally and spatially limited information
- A river or basin wide or even national monitoring of all waters is complex to manage and very expensive
  - Risk assessment for hundreds of known dangerous substances and thousands of potential harmful substances in entire river basins only via monitoring is impossible
- **This is where models can help!**

The GREAT-ER model

Georeferenced **R**egional **E**xposure **A**ssessment **T**ool for **E**uropean **R**ivers

- Combines GIS with fate models to consider the overlying effects of multiple emissions
- GREAT-ER 4.1 implemented as Add-In for ArcGIS® Desktop 10.5

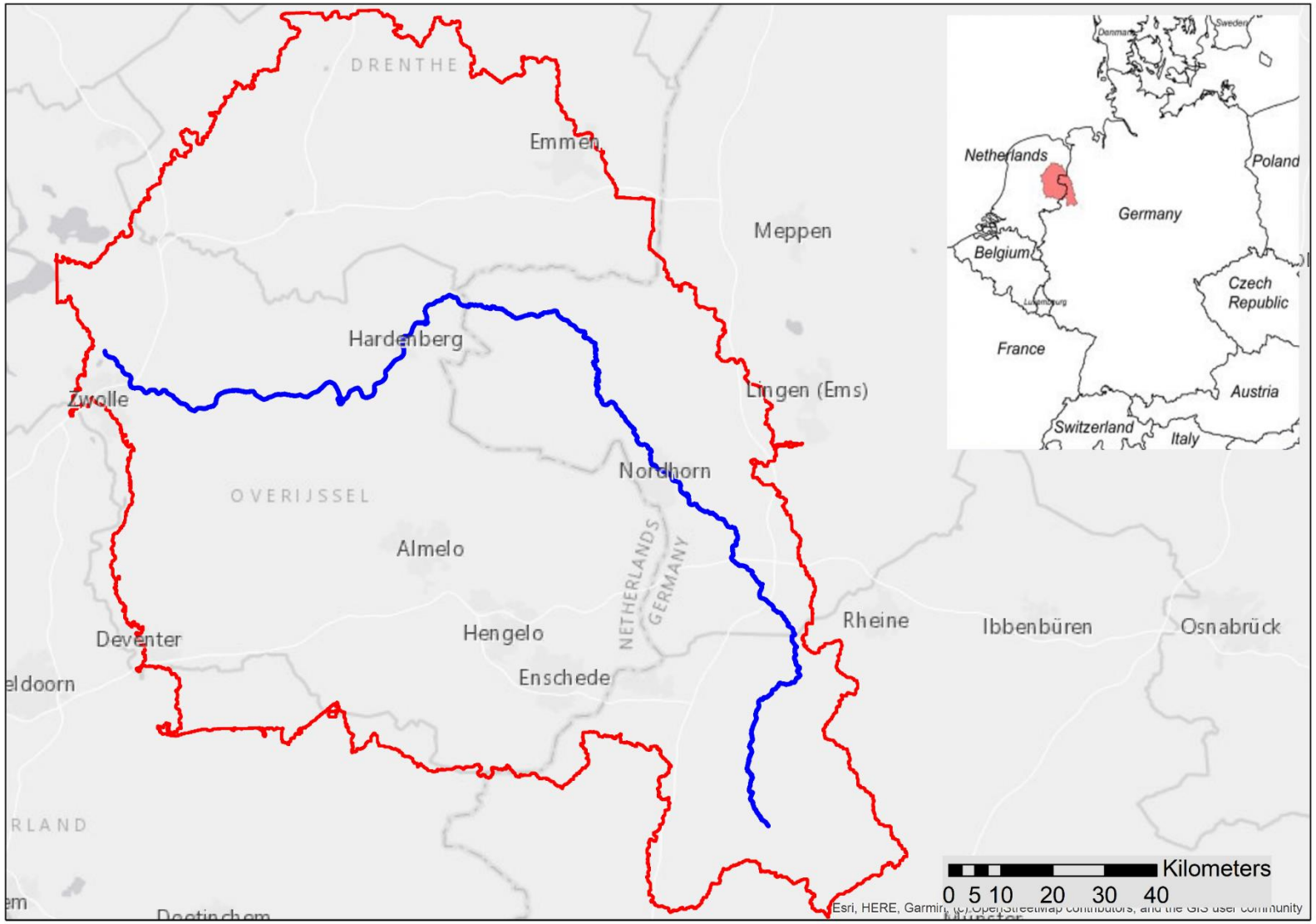
Model approach

- Real river network of the whole watershed (as segments)
- Consider local emissions from all known sources
- Mass balance for each river segment
- Simulate spatially resolved concentrations assuming steady state conditions
- Georeferenced representation of the results

Model restrictions

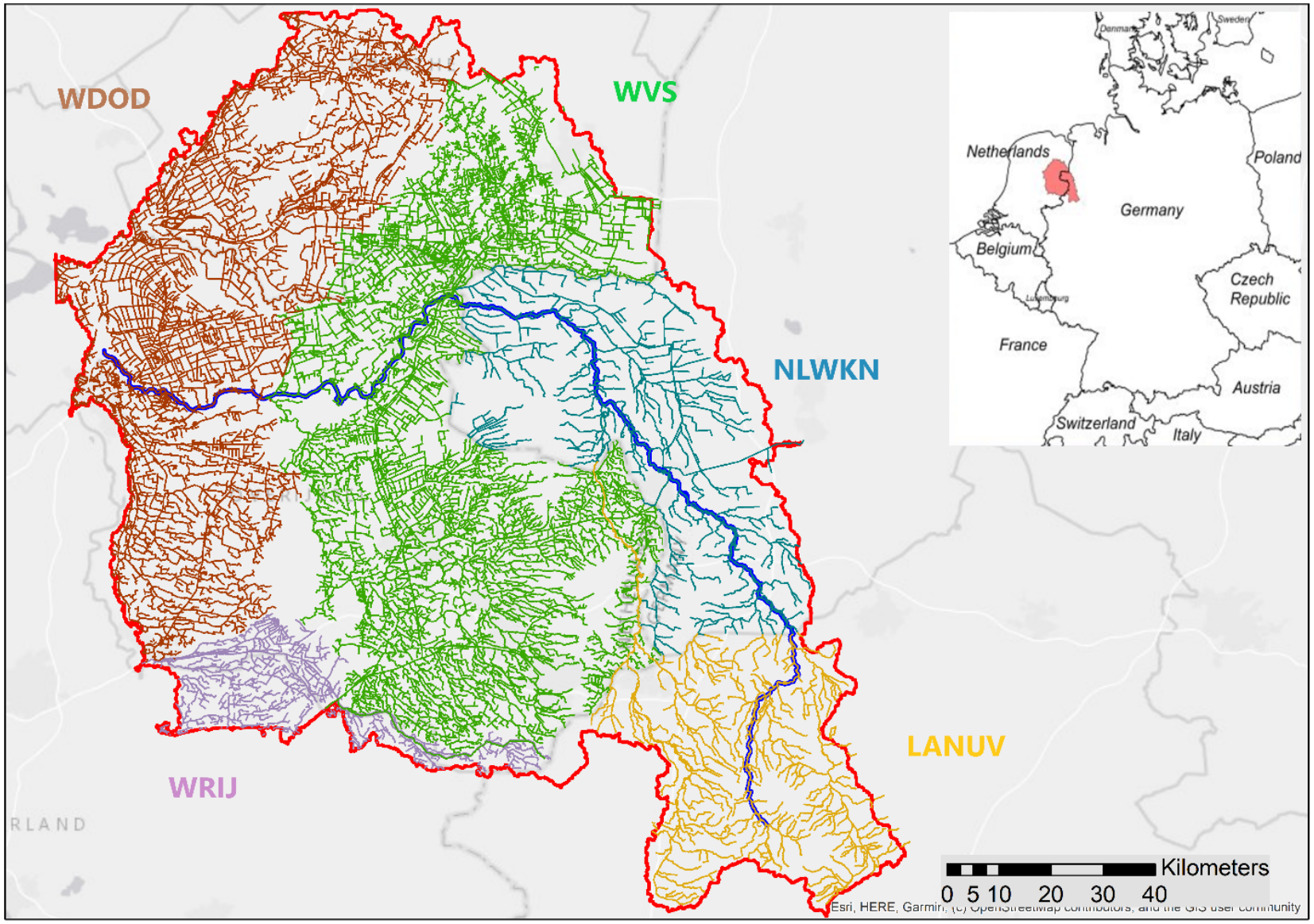
- GREAT-ER model simulations are based on steady-state assumption
  - requires more or less constant emissions (annual averages)
  - temporal dynamic events can not be modeled

Research area



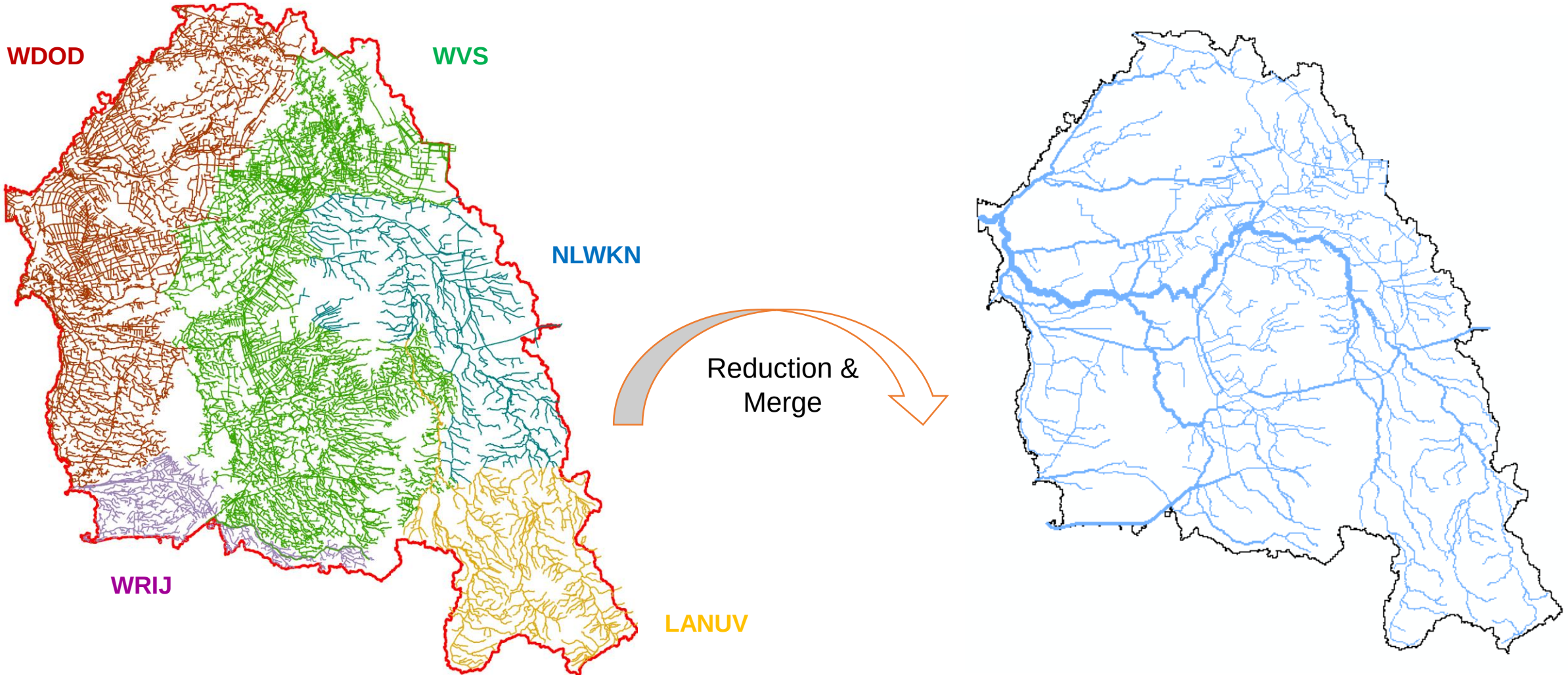
- Length: 182 km
- Area: 5,740 km²
- Source: Near Münster
- Estuary: North of Zwolle (Zwarte Water)
- Discharge:
  - Avg.: 35 m³/s
  - Low flow: 3 m³/s
- Biggest Cities:
  - Enschede (~150,000)
  - Zwolle (~125,000)
  - Emmen (~100,000)
  - Nordhorn (~50,000)
  - Steinfurt (~35,000)
- Total: ~ 1,5 million

Authorities

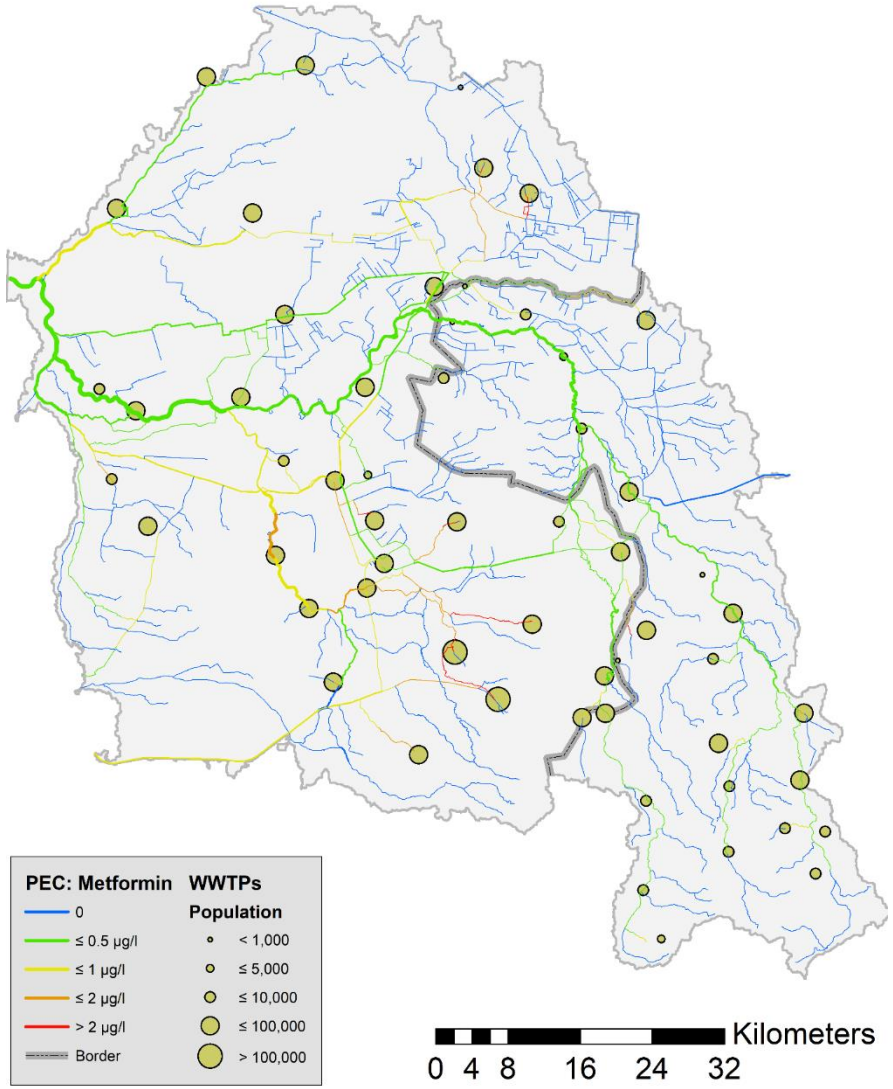


- **Waterschap Drents Overijsselsche Delta (WDOD)**
- **Waterschap Vechstromen (WVS)**
- **Waterschap Rijn en Ijssel (WRIJ)**
- **Niedersächsische Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz (NLWKN)**
- **Landesamt für Natur, Umwelt und Verbraucherschutz Nordrhein-Westfalen (LANUV)**

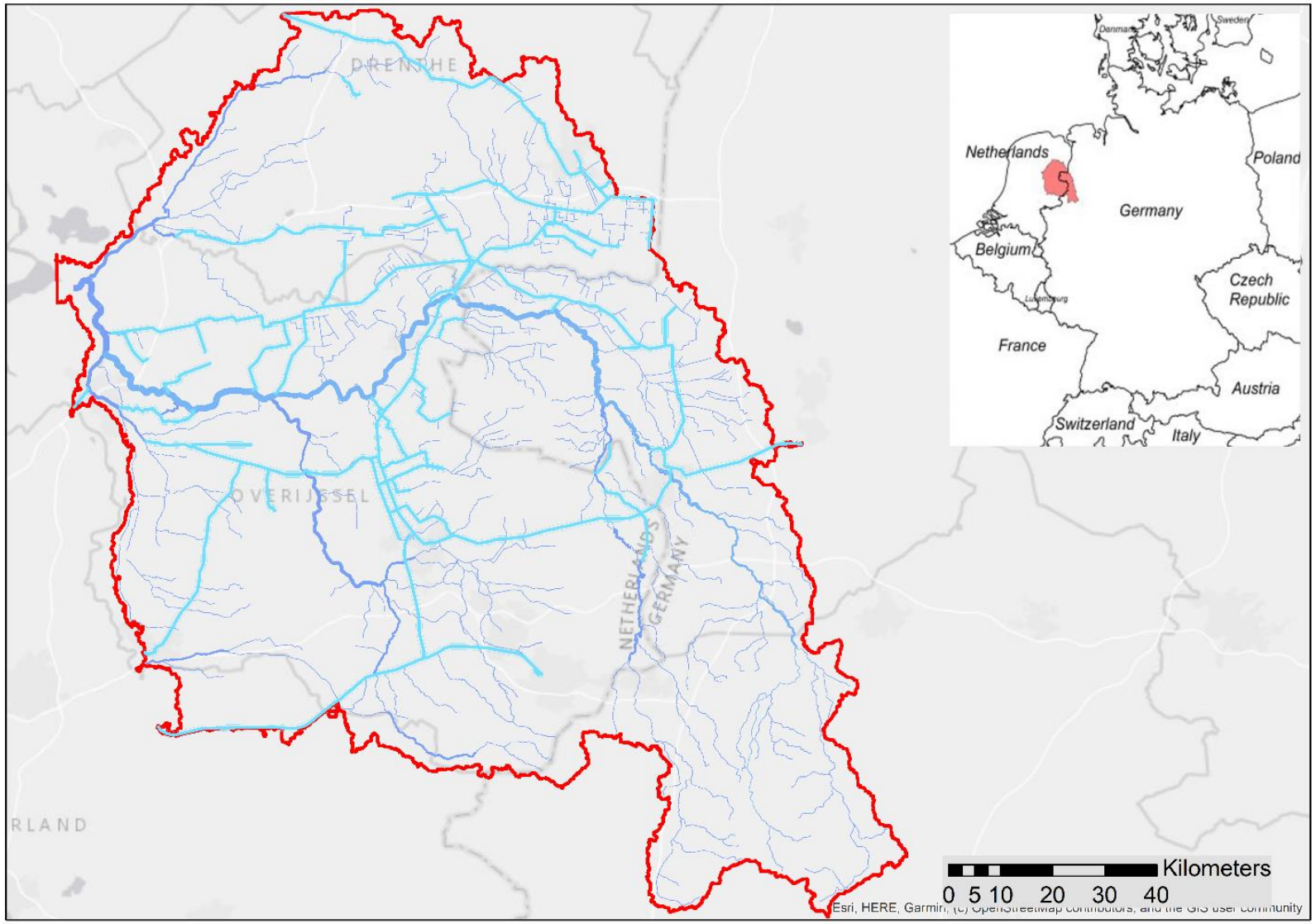
Creating the hydrological network



Exemplary simulation results



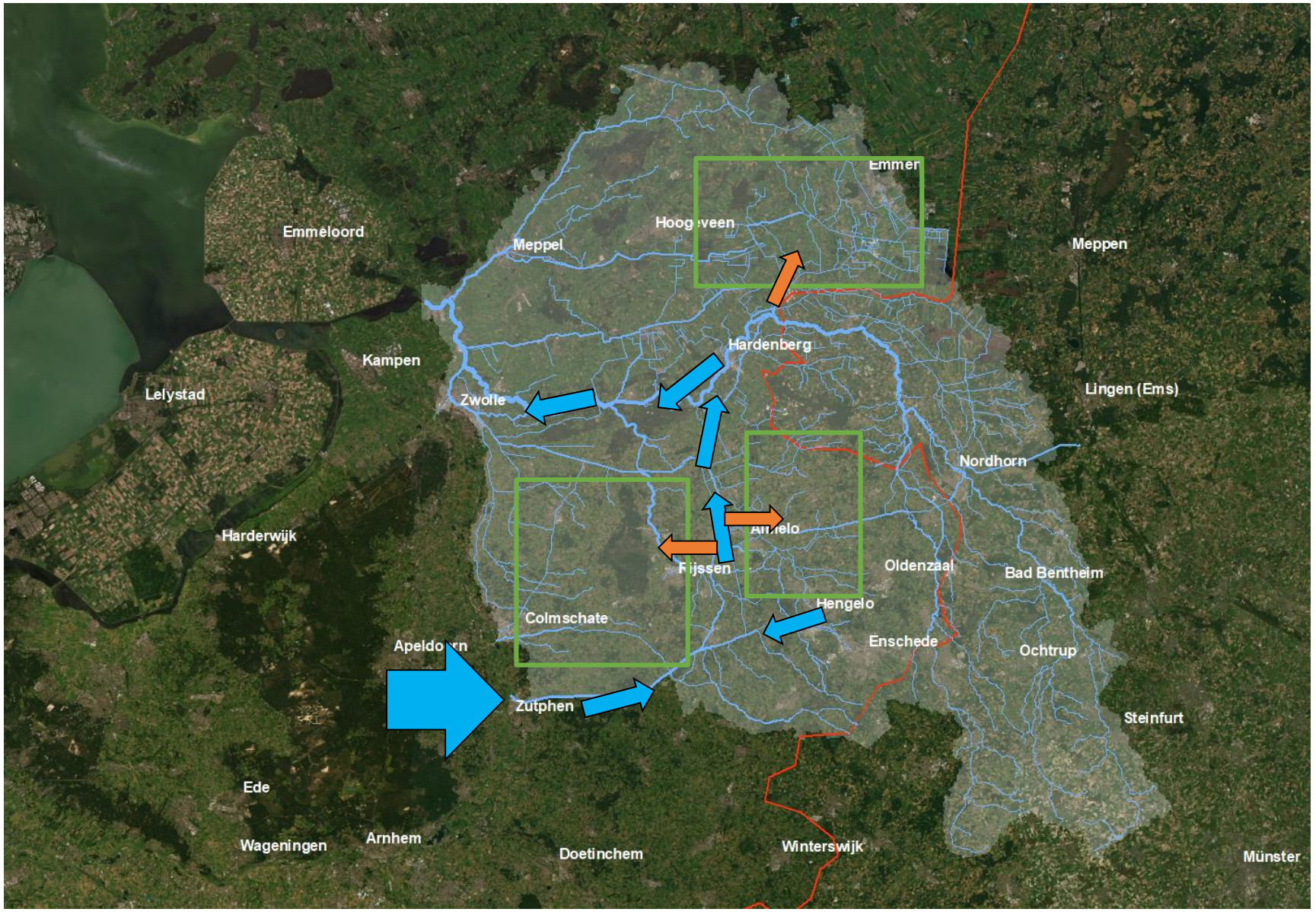
Canals



- Canals:
  - Twentekanaal
  - Nordhorn-Almelo-Kanal
  - Overijssels Kanaal
  - Kanaal Almelo-De Haandrik
  - Dedemsvaart
  - Coevorden-Picardie-Kanal
  - (Meppelerdiep)

- ~30% canal-like structures

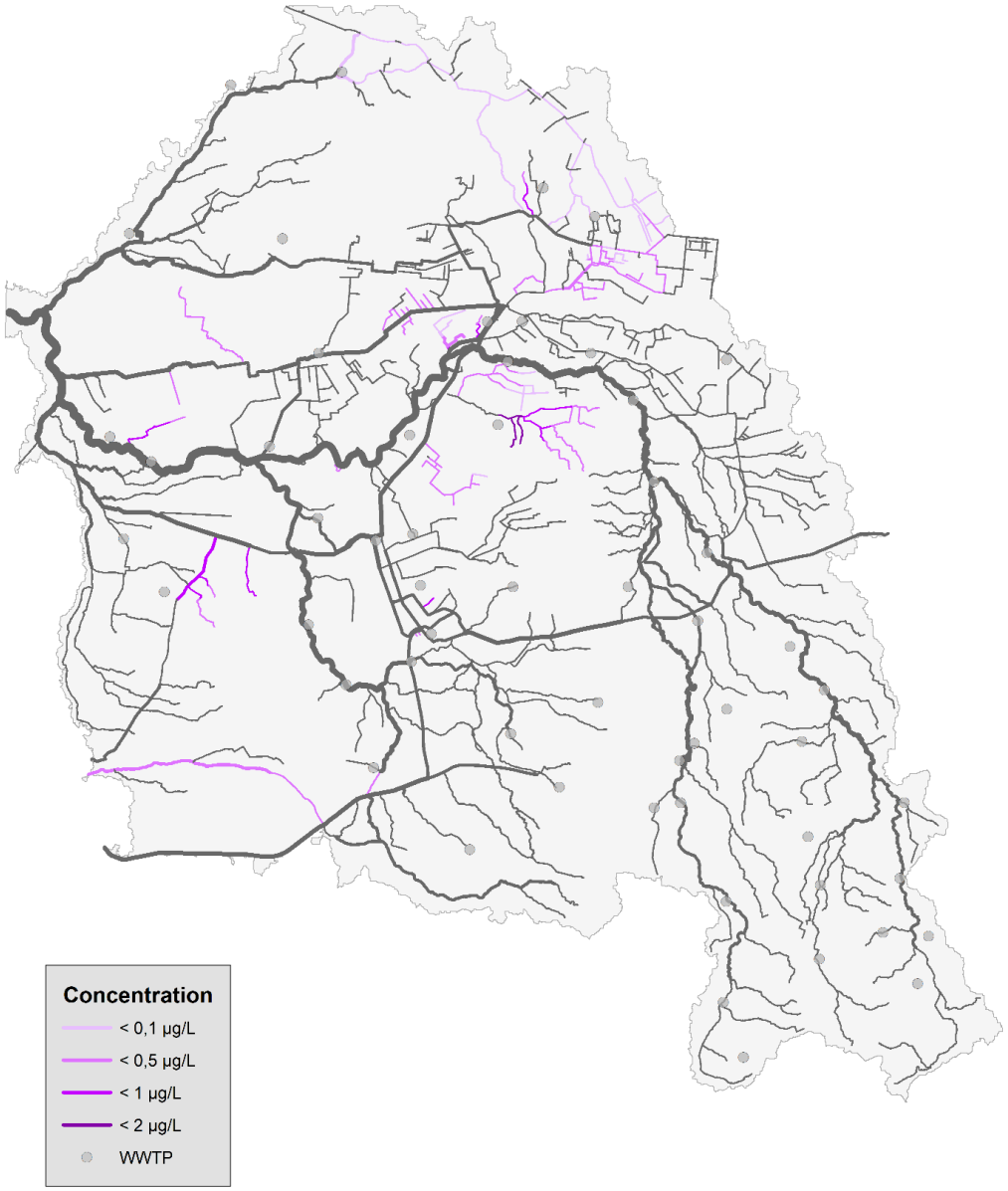
Pumping activities



Scenarios

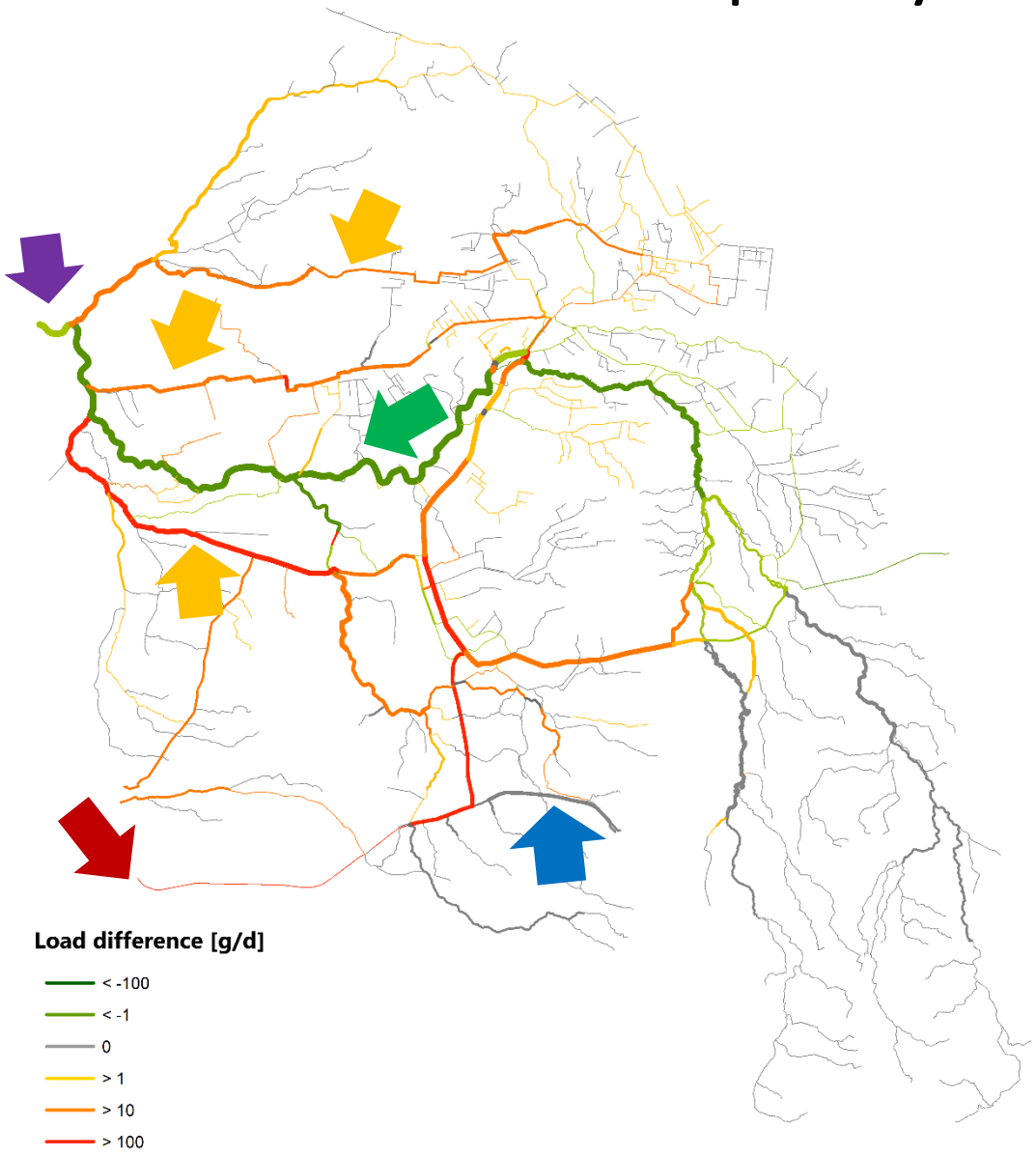
	Dry-Summer-Scenario	*Average-Condition-Scenario*
Applicability	Dry periods without rainfall between March and October	Humid periods throughout the whole year
Pumping activity	Yes	No
Pumping description	120 days a year between March and October (Netherlands)	-
Pump power “Eefde” (Zutphen) [m^3/s]	1.6 (mean); 14 (maximum)	-
Pump „Delden“ (Enschede)	Yes	Yes
Changes in flow direction	Yes	No
	Twente Canal, Zijkanaal Almelo, Canal Almelo-De Haandrik, and several emerging smaller canals	-

Pumping activities



- ~120 pumping days a year
  - Introducing additional loads into the catchment
- Additional 15% of the river network is now affected
  - (= 412 km of river length)

Exemplary simulation



Situations on pumping days [Metformin]:

1. Additional loads (0.28 Kg/d) enters the catchment area through the Twente Canal
2. Pumps in Enschede are still running
3. Less loads in the Vecht on pumping days
4. Above/below the Vecht the canals (Meppelerdiep, Dedemsvaart, Overijssel Canal) have higher loads → Redistribution of emissions
5. At the outlet point (Zwarte Water) the difference is minimal again

Paper (under revision)

- **Geo-referenced simulation of pharmaceuticals in whole watersheds - Application of GREAT-ER 4.1 in Germany**
  - Volker Lämmchen, Gunnar Niebaum, Jürgen Berlekamp, Jörg Klasmeier

Paper (in preparation)

- **Modelling of micro-pollutants in a strongly regulated cross-border lowland catchment**
  - Volker Lämmchen, Jörg Klasmeier, Lucia Hernandez, Jürgen Berlekamp

Thank you for your attention!