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Calculating emissions to water – a simplified method implemented as a spatially and temporally distributed model

RIVER BASINS 2024

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ICPDR IKSD

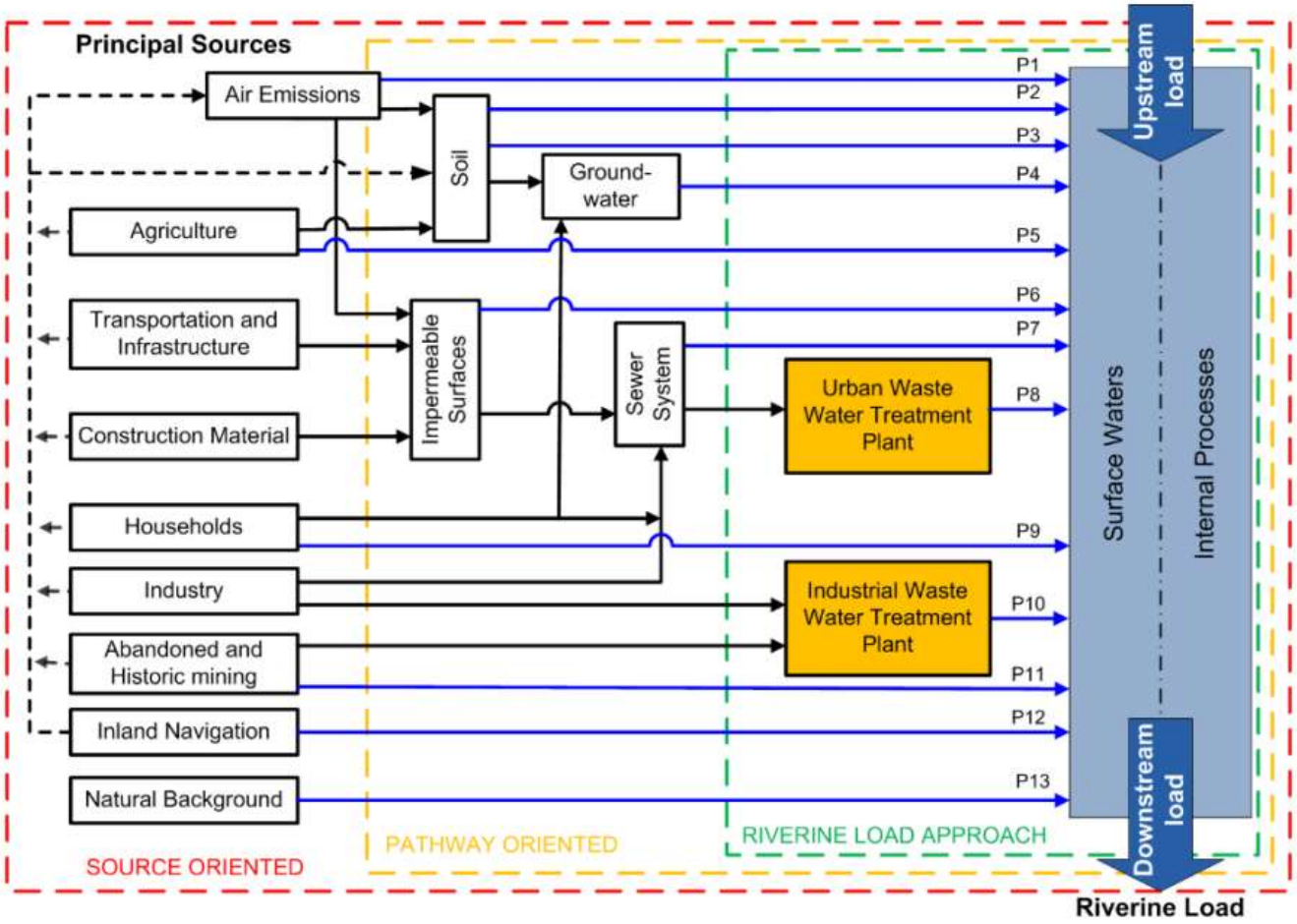
International Commission for the Protection of the Danube River

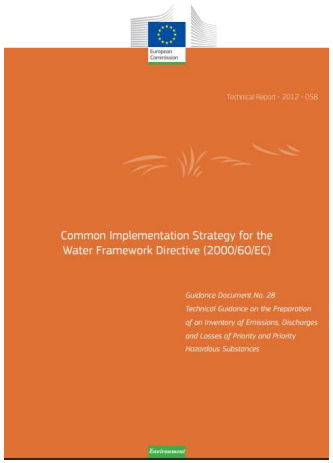
Internationale Kommission zum Schutz der Donau

Introduction

- The European Green Deal formulated the Zero Pollution Ambition
- In the context of river basin management, this ambition relies on baseline information on the quantities of pollutants released to surface waters (“emissions”)
  - Quantitative understanding of sources and pathways
  - Formulation of (cost-)effective programmes of measures
- This information is still lacking in many cases
- Complicating factors
  - Many potentially relevant substances (Priority and priority Hazardous Substances, River Basin Specific Pollutants, Contaminants of Emerging Concern, micro-plastics, pathogens, antibiotic resistance)
  - Global (Climate) Change and Adaptation Processes

Water Framework CIS





- Technical Guidance Document 28
- on the Preparation of an Inventory of Emissions, Discharges and Losses of Priority Substances
- methods of increasing sophistication (“tiers”)
- “tier 4”: source oriented modelling based method

Calculating emissions to water – a simplified method
(EEA; ETC/ICM Report 3/2022)

- Further elaboration of TGD, as experience from the second River Basin Management Plans showed that Member States needed further information to help them report in a more consistent and comparable way
- Quantification methods for the 13 pathways for emissions to surface waters referred to in the TGD
- Baseline information on priority substances concentrations and emission factors, relevant to European countries
- Systematic “factsheet” format
  - introduction describing the pathway and the substances most relevant to that pathway
  - explanation of calculation methods to quantify the emissions from that pathway
  - detailed annexes with data about emission factors and calculated emissions per country
- Non-binding
- Starting point for EU wide estimates
- Can (should) be supplemented by local data for regional inventories

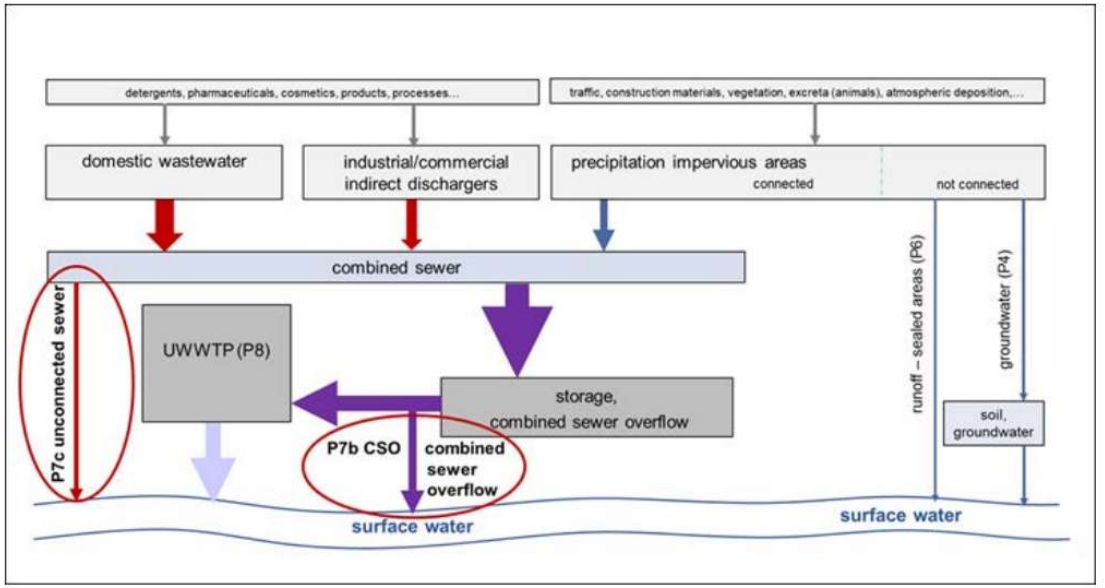
Stormwater outlets/combined sewer overflows and unconnected sewers (P7)

Scheme showing:

- P7b: CSOs
- P7c: unconnected sewers

Supportive data, e.g.

- Combined vs separate sewers at country level



Country*	Percentage of separate sewers	Percentage of combined sewers
Austria	71.5	28.5
Belgium (mean)	10	90
Bulgaria	n/a	majority
Croatia	41	50
Cypris	100	0

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An application

- Copper
- EU27

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Sources of copper into the European aquatic environment

Sean Comber,[1,] Genevieve Deviller,[2] Iain Wilson,[3] Adam Peters,[3] Graham Merrington,[3] Pasquale Borrelli,[4] and Stijn Baken[5]*

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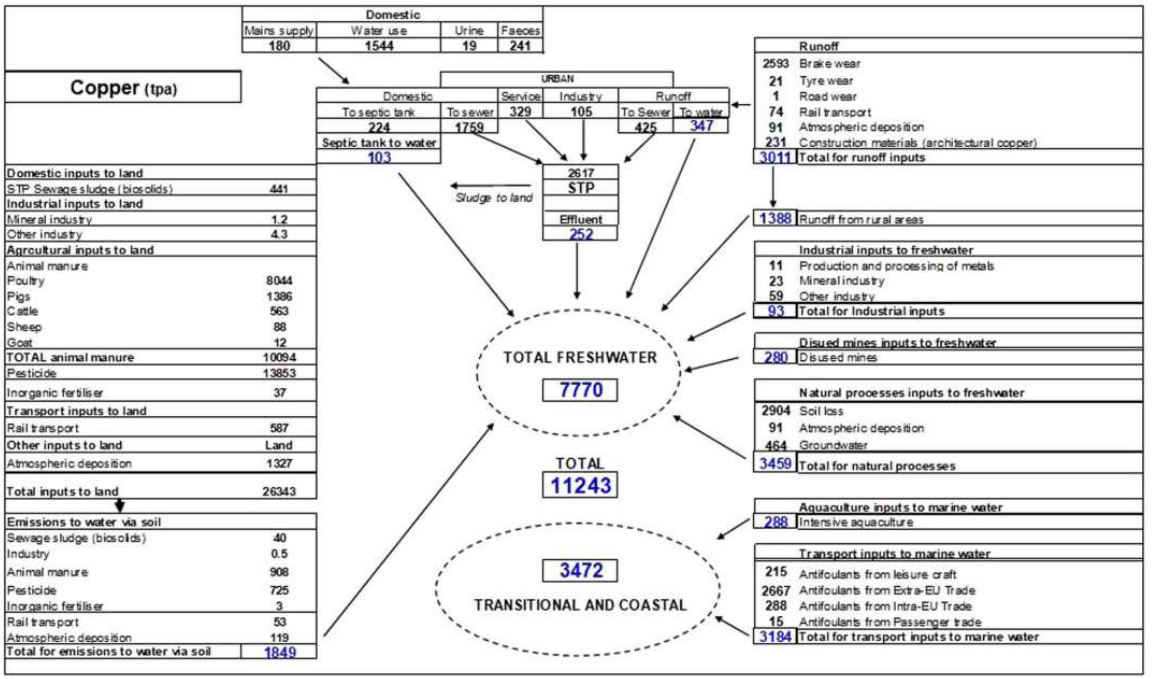

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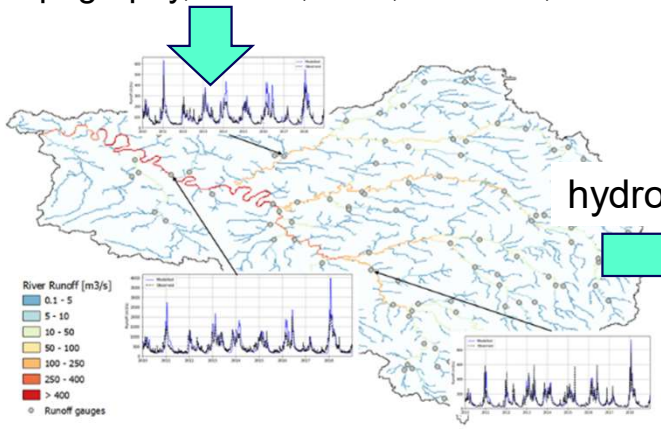
Spatially and temporally explicit modelling

Open global data as a starting point

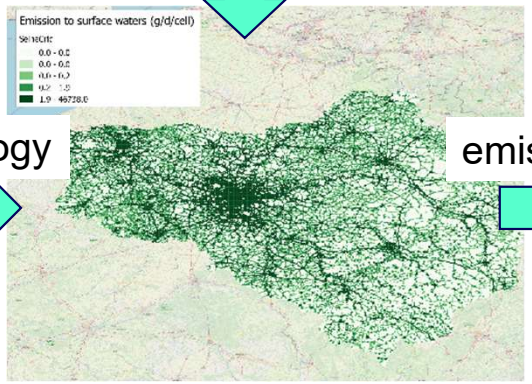
topography, meteo, soils, land use, lakes

socio-economic data

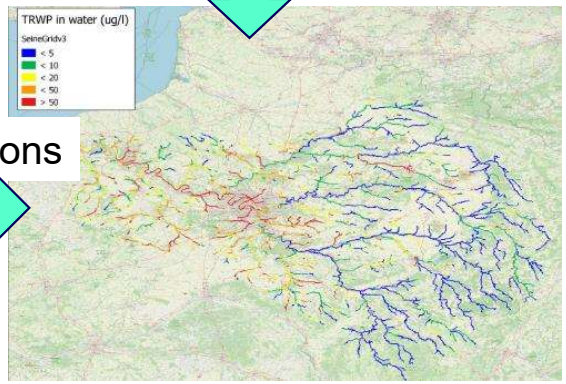
biogeochemical info



hydrology



emissions



Wflow

D-Emissions

D-Water Quality

Open source software

HydroMT data processing

Hydrological Modelling Tools

- (Good) data becomes more widely available
- At higher temporal and spatial resolution
- As the data improve, we want to improve our models

- HydroMT functionality:
  - Operate on these datasets
  - Are easy to use (for modelling experts)
  - Support the modellers by doing the “hard” & “boring” work
  - Support developments in enhancing these datasets
  - Support re-using methods and workflows for different models

- “three clicks to a model”
- Everything except socio-economic and substance specific data

GIS processing

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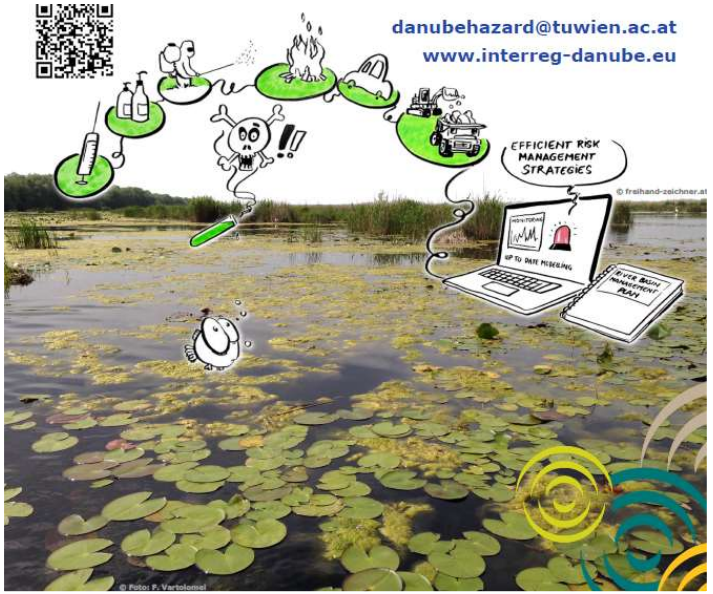
Danubehazard m3c project

- Danube River Basin (DRB)
- Durable and effective transnational control and reduction of hazardous substances (HS) water pollution
- Key components
  - collection of existing data and complementary monitoring
  - modelling at different spatial scales
  - WFD compliant management practices
  - capacity building



Interreg
EUROPEAN UNION
Danube Transnational Programme

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Danube Hazardous Substances Model (DHSM)

Methodology

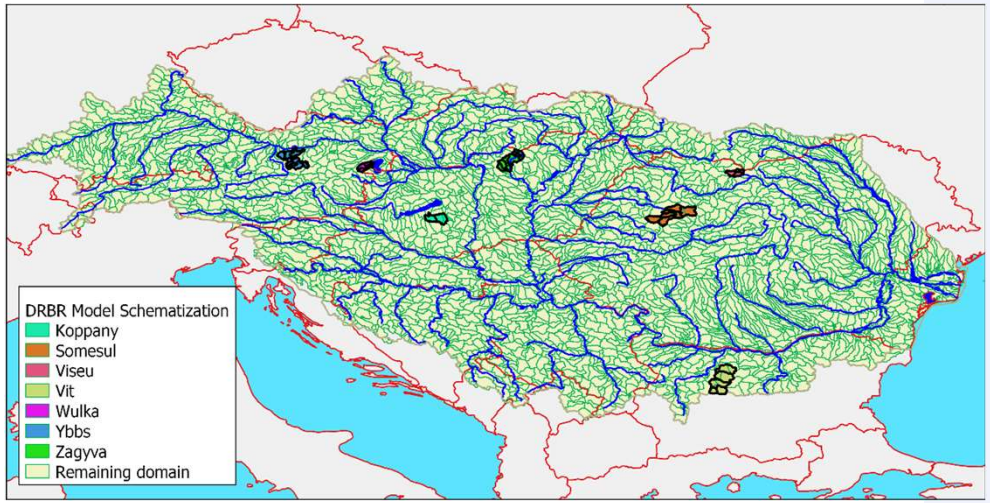
- WFD TGD 28 / ETC/ICM Report 3/2022
- Spatially and temporally explicit modelling

Data

- International Commission for the Protection of the Danube River (ICPDR) inventories
- Specific information from DanubeHazard m3c

Substances

- 17 relatively “data rich” substances, representing a spectrum of priority sources and pathways
- Results assumed representative for managing a much wider spectrum of substances



Implementation

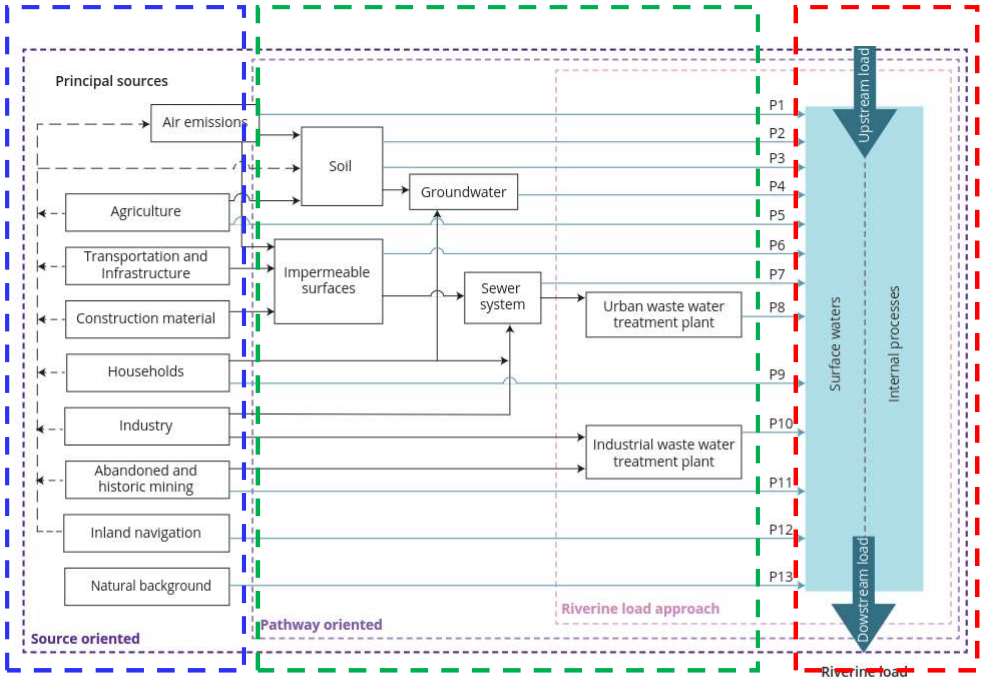
"Source oriented" approach

1. Quantify Sources, and allocate to initial receptor (e.g. paved surfaces, top soils, sewers)
2. Trace substances pathways
   - Wastewater management
   - Stormwater management
   - Soil system
3. In-stream fate and transport (water quality model)

Steps 1-2: emission inventory

Step 3: resulting surface water concentrations

- Model validation
- Evaluate emission reduction measures



P1, Atmospheric deposition directly to surface water
P2, Erosion
P3, Surface run-off from unsealed areas
P4, Interflow, tile drainage and groundwater
P5, Direct discharges and drifting
P6, Surface run-off from sealed areas
P7, Stormwater outlets and combined sewer overflows and unconnected sewers
P8, Urban waste water treated
P9, Individual (treated and untreated) household discharges
P10, Industrial waste water treated
P11, Direct discharges from mining
P12, Direct discharges from navigation
P13, Natural background

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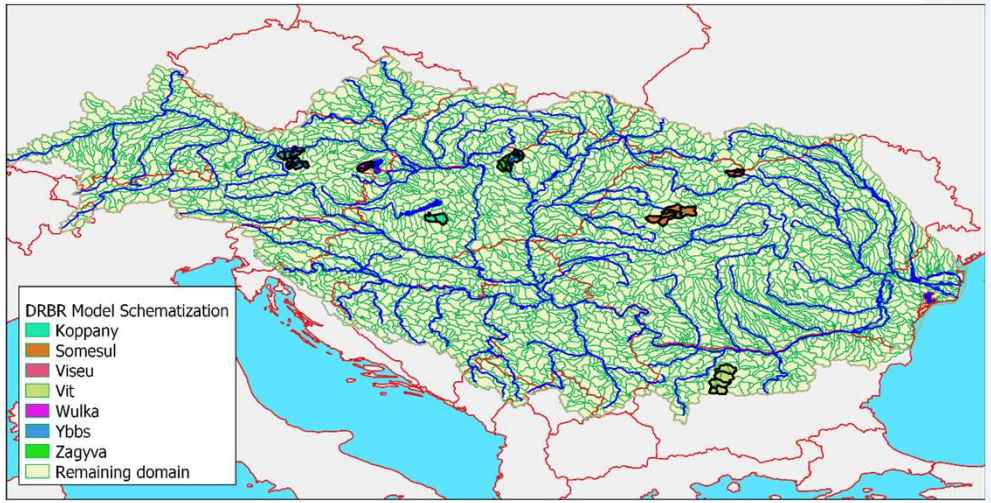
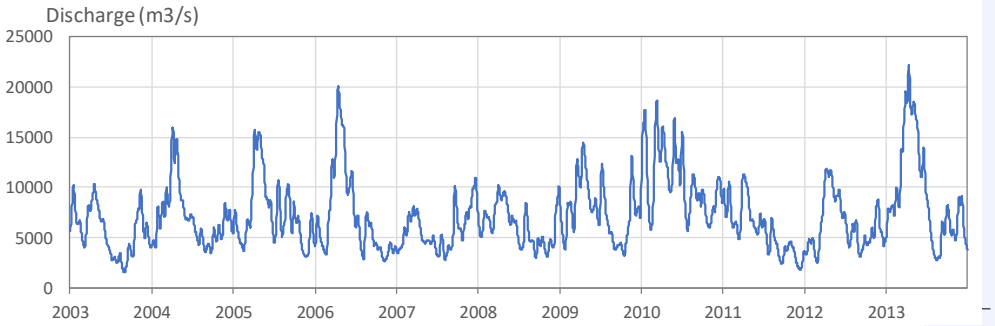
Danube Hazardous Substances Model (DHSM)

- Sources and pathways variable in space
- HS fluxes along pathways are time-dependent, controlled by hydrology
- Events are resolved, e.g.
  - combined sewer overflows,
  - first flush of paved surfaces after dry periods
- Inter- and intra-annual variability is resolved
  - differences in emissions
  - differences in dilution
  - wet years, dry years





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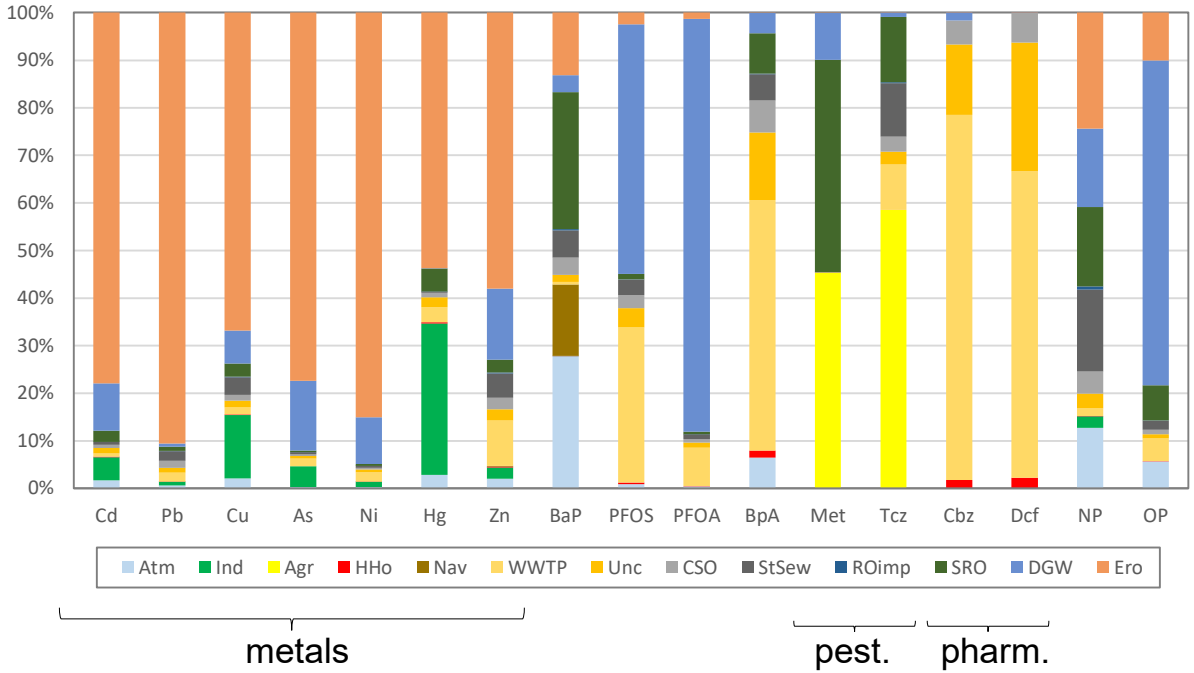
DHSM results

- Calculated emissions of 17 chemicals
- Distributed over pathways (as in the WFD CIS Guidance)
- Mass balance of all compartments (insight)
- Quantified uncertainty of emissions
- Quantified variability of emissions between years
- Spatial variability (countries)
- Uncertainty and variability of concentrations
- Scenarios (emission control)

Distribution over pathways (basin wide)



full report available from
https://www.interreg-danube.eu/approved-projects/danube-hazard-m3c/outputs

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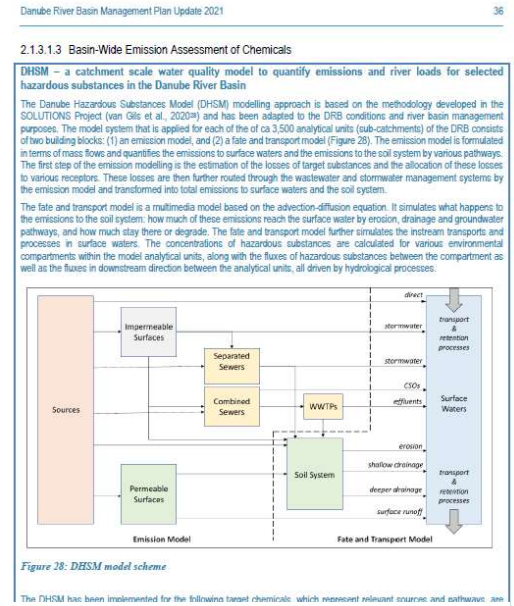
Useful for RBM

- HS emission inventory for the Danube River Basin first time ever
- Understanding of regional hot-spots, river loads to Black Sea
- Realistic pathway and source apportionment for the target chemicals
- Tool for future risk assessment regarding WFD compliance
- Tool for management and climate change scenario analysis
- Direct inputs to the DRBMP Update 2021 and its future versions

https://www.icpdr.org/library/publications/management-plans



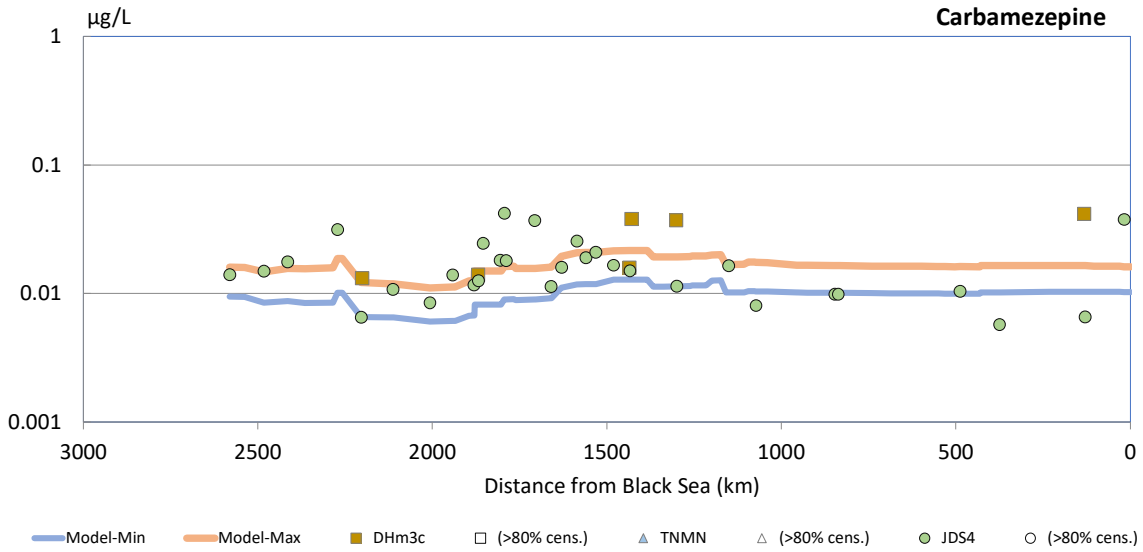
Model validation

Measured vs simulated in-stream concentrations, how good is it?

- Often reasonable results
- Pesticides and industrial chemicals are problematic

Not shown

- Calibration/validation also possible along pathways
  - collected stormwater



The uncertainty of the emission estimates increases with decreasing spatial scale

- many spatially variable input quantities and emission factors could only be quantified country-by-country or even Europe-wide.

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Consistent interpolation and extrapolation

- Country-by-country emissions of copper (using ETC/ICM method)
- What are emissions to the DRB?
- Which share of loads from Germany need to be allocated to the DRB?
- Same question for other countries

Environmental Management

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- Proportionality to surface area or population?
- In reality this will depend on sources, pathways
- Using spatially and temporally resolved modelling
  - a consistent answer
  - reflects dependency on sources and pathways

Take home messages

- The question is clearly formulated (WFD TGD 28): emission inventories are needed for RBM
- The WFD CIS TGD 28 has recently been complemented with EEA; ETC/ICM Report 3/2022
- The recently completed DHSM combines these guidances with spatially and temporally explicit modelling
- Automatic processing of global data provides a lot with a limited effort
- Substantial effort needed on some socio-economic and substance specific input data (strong dependency on field data)
- The approach has been demonstrated to produce results useful for RBM
  - Diagnostic and prognostic capabilities
  - Consistent spatial and temporal gradients
  - Feasible for a range of chemicals representing key sources and pathways
- Effective use can be made of open (global) datasets – options to include climate change projections
- Uncertainty increases with decrasing spatial scale

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