

11<sup>e</sup> Conférence internationale

LYON 2023

— L'eau dans la ville | Urban water

Organisée par

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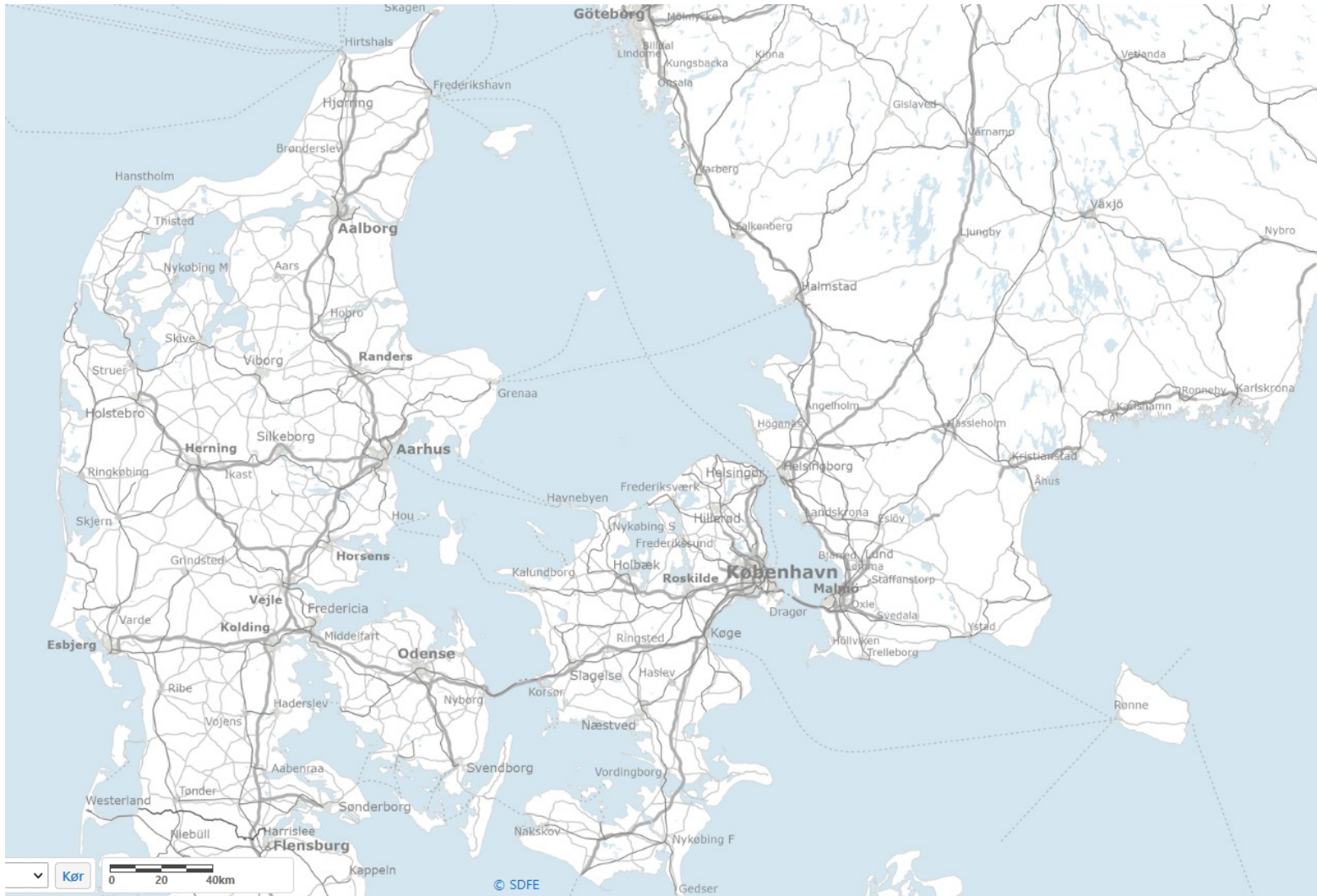
nôvateCH

L'eau dans la ville | Urban water

**Un modèle de prédiction pour détecter les impacts des déversoirs d'orage sur la qualité chimique des cours d'eau danois**  
*A chemical fate model for screening impacts from wet-weather discharges on Danish streams*

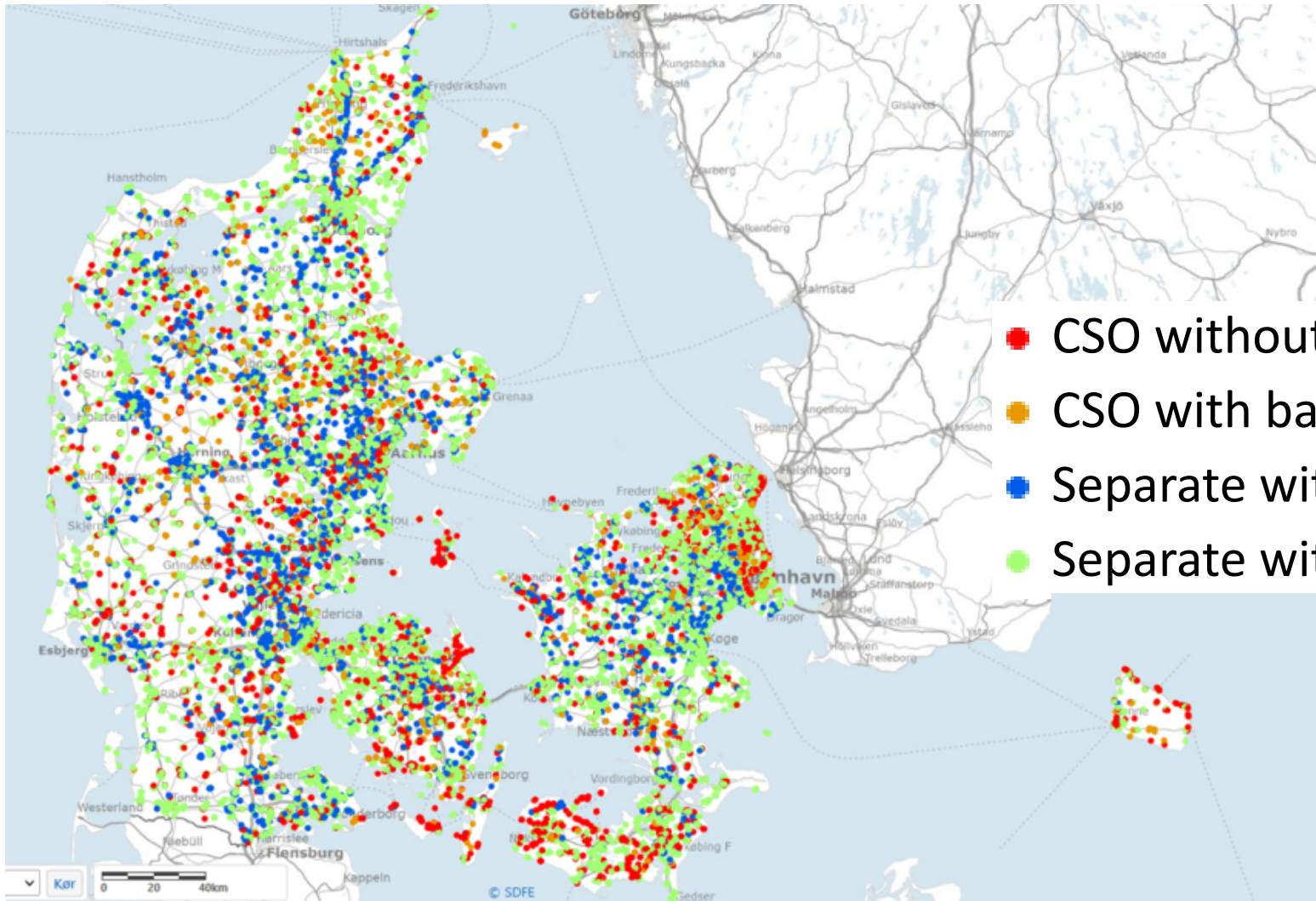
Vezzaro Luca, Schweiger Leonie, Mutzner Lena

# Why this study?



This is Denmark

# Why this study?



This is Denmark  
(seen by an urban  
water engineer)

- CSO without basin
- CSO with basin
- Separate without basin
- Separate with basin

~4,500 CSO

~15,000 separate  
outlets

# Regulating wet weather discharges

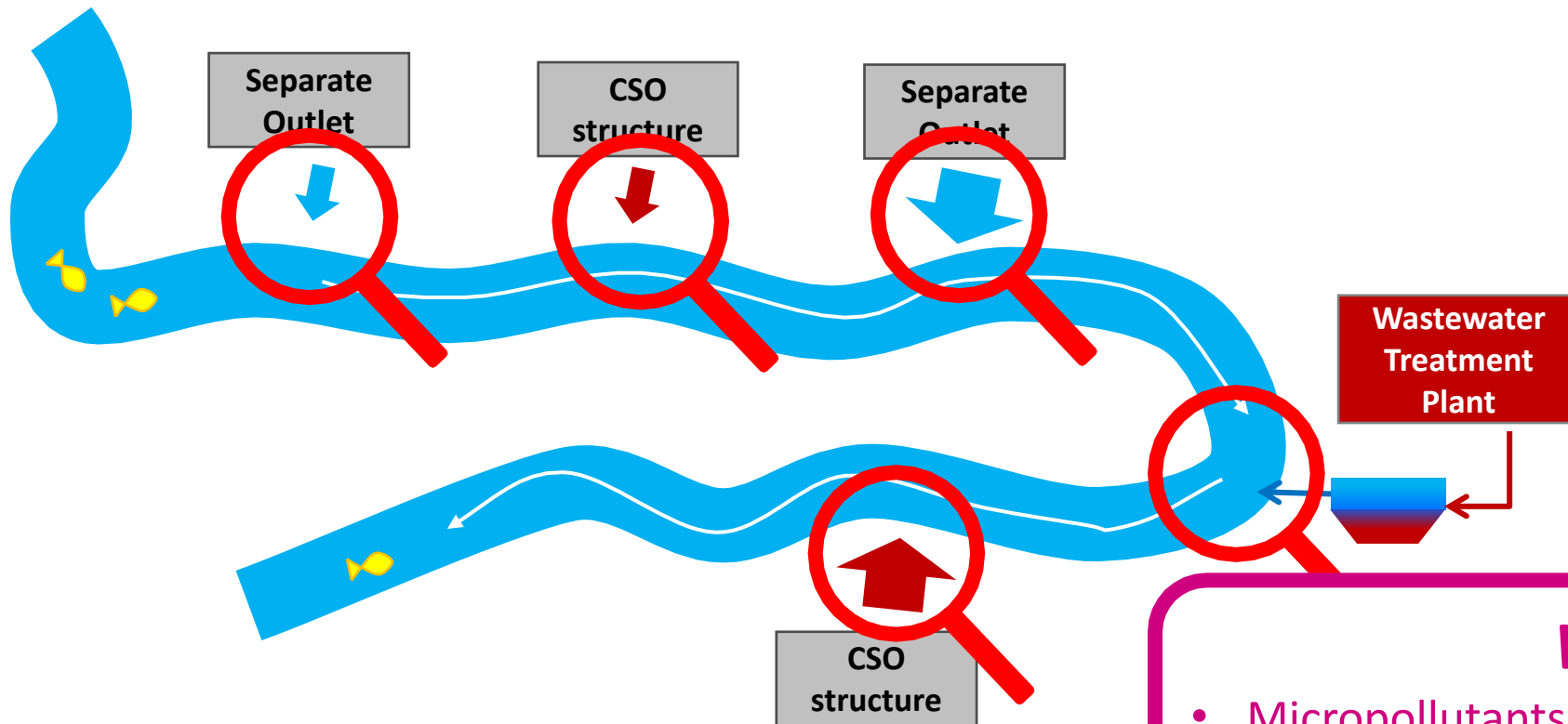
- Each discharge has a permit.... **BUT**



utility



regulators



Focus on

- Individual discharges
- Nutrients

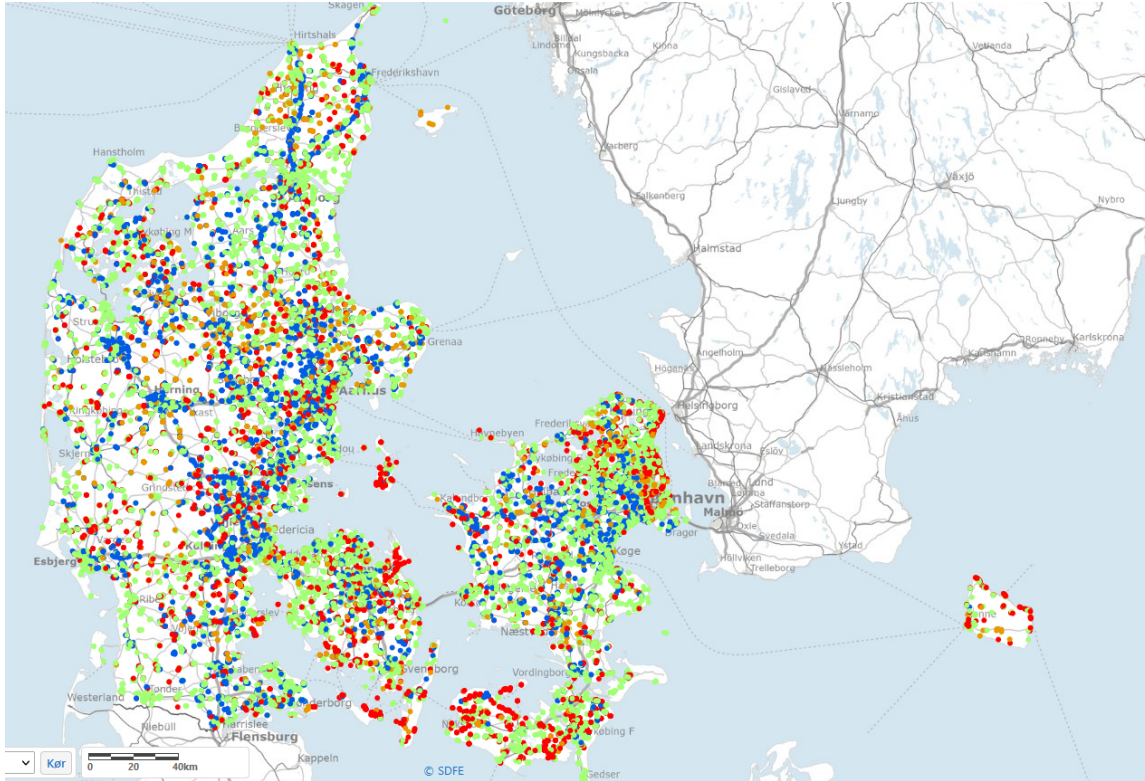
(chronic effects => loads)

## *What about*

- Micropollutants (acute effects => concentrations)?
- Integrated assessment (whole receiving water body)?

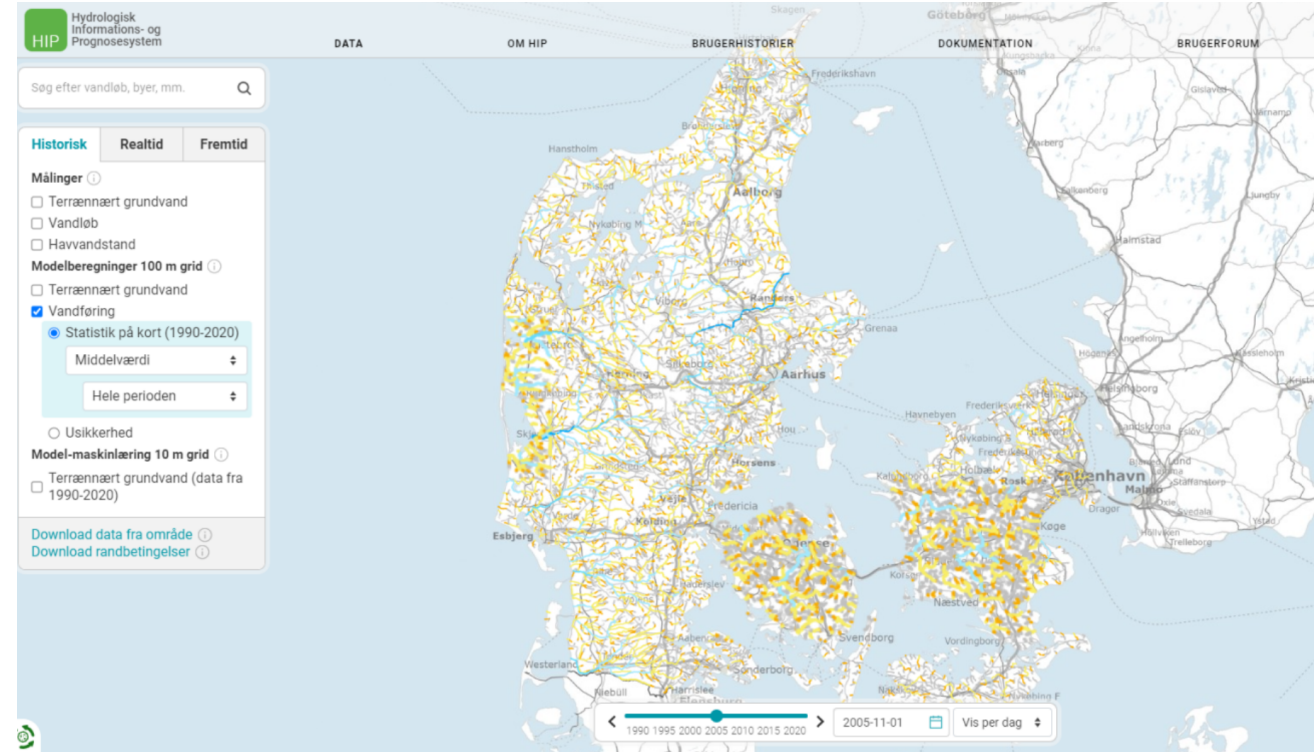


# Our modelling approach - use open data



DK Environmental portal  
(<https://arealinformation.miljoeportal.dk/>)

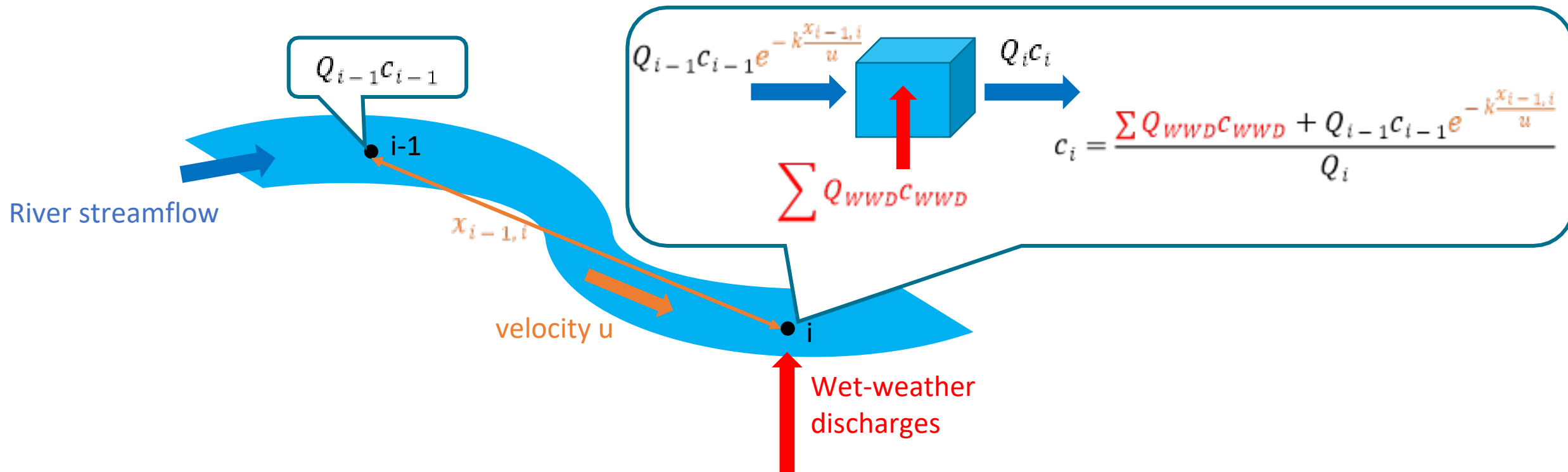
**Discharge points**  
**Yearly volumes**



Hydrological and Information Prediction system  
(<https://hip.dataforsyningen.dk/>)

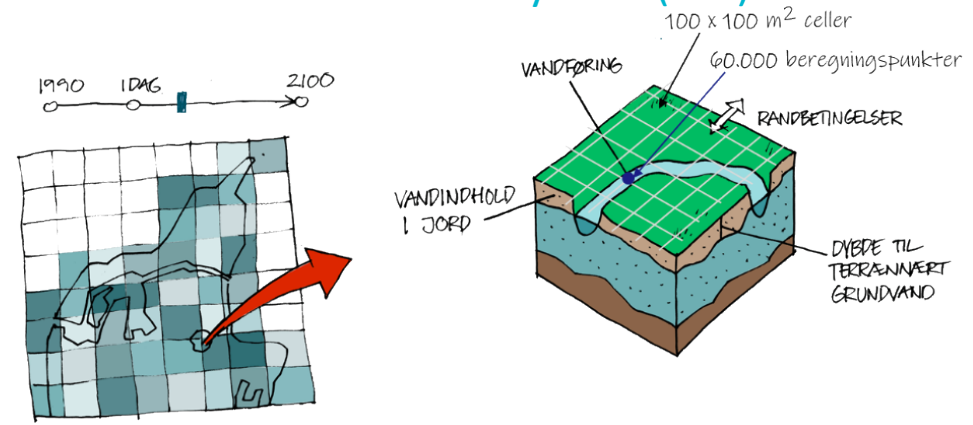
**Modelled (and measured) monthly flow**  
**All Danish streams and creeks**

# Modelling approach – simple fate model



# Modelling approach – simple fate model

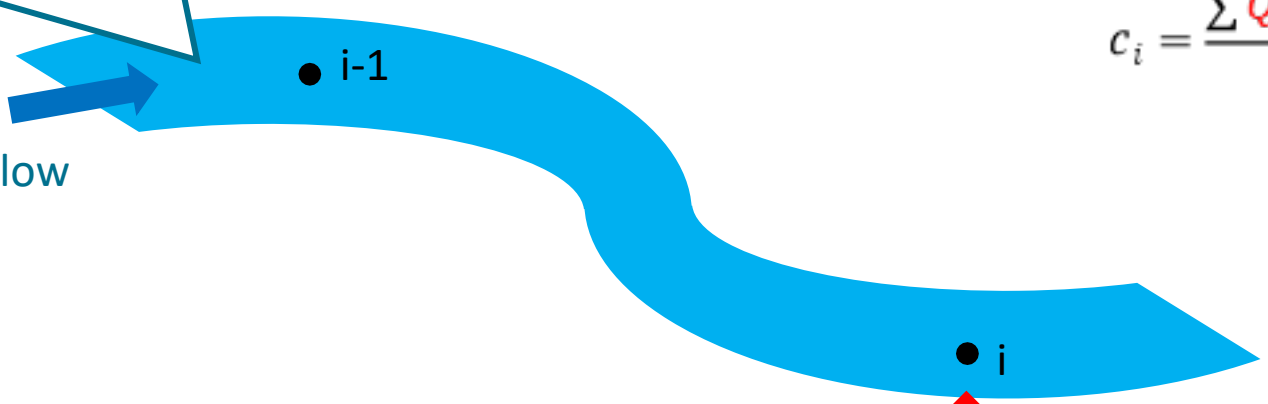
Monthly streamflow data from the Danish Hydrological Information and Prediction System (HIP)



Discharged volumes from PULS database

Measured Concentrations from literature

River streamflow



Wet-weather discharges

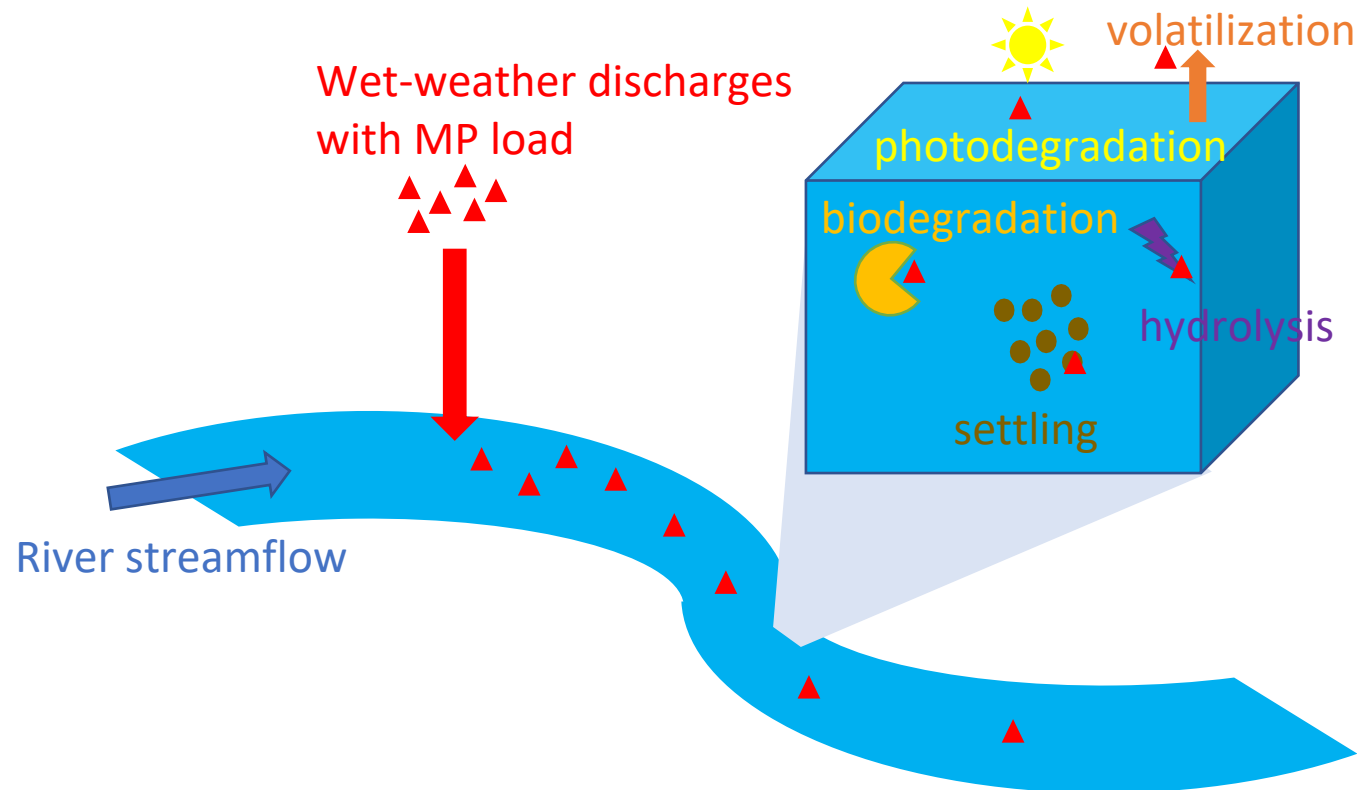
$$c_i = \frac{\sum Q_{WWD} c_{WWD} + Q_{i-1} c_{i-1} e^{-k \frac{x_{i-1,i}}{u}}}{Q_i}$$

Fate processes

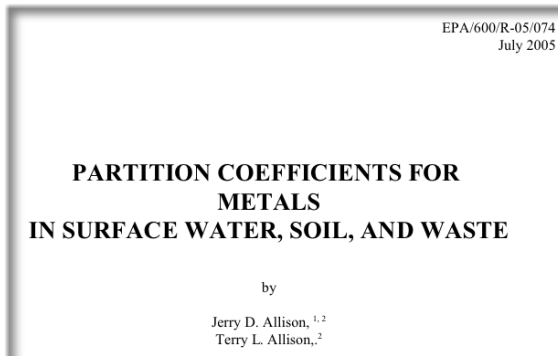
# Modelling approach – simple fate model

- First order processes
- Partitioning (dissolved/particulate)

$$k = f_{sorbed} k_{sed} + f_{diss} k_{vol} + f_{diss} k_{photo} + f_{diss} k_{bio} + f_{diss} k_{hyd}$$



PubChem



Physico-chemical properties  
Partitioning coefficients  
Biodegradation/ hydrolysis/ photolysis half lives



# How much removal can we expect?

Most half lives > 100 h



no significant removal in rivers expected

Substance	k_sed (1/s)	k_bio (1/s)	k_photo (1/s)	k_hyd (1/s)	k_vol (1/s)	k (1/s)	DT50 (h)
Barium	1.2E-07					1.2E-07	1642
Cadmium	4.9E-07					4.9E-07	393
Chromium	6.0E-07					6.0E-07	322
Cobalt	4.4E-07					4.4E-07	440
Copper	2.3E-07					2.3E-07	842
Lead	7.7E-07					7.7E-07	250
Mercury	5.2E-07				2.9E-06	3.4E-06	56
Nickel	2.5E-07					2.5E-07	783
Selenium	2.5E-07					2.5E-07	769
Tin	5.0E-07					5.0E-07	387
Uranium	6.9E-10					6.9E-10	280891
Vanadium	6.4E-08					6.4E-08	3012
Zinc	4.4E-07					4.4E-07	439
4-tert-Octylphenol	1.0E-08	1.5E-07	6.9E-07		8.7E-07	1.7E-06	113
Bisphenol A	9.2E-10	2.0E-06			3.4E-12	2.0E-06	96
DEHP	1.7E-08	1.5E-08	1.3E-08	6.4E-13	1.2E-09	4.6E-08	4166
para-Nonylphenol	2.1E-08	1.1E-07			3.0E-06	3.1E-06	62
PFOS	3.1E-09			5.3E-10	5.7E-10	4.2E-09	46224
Anthracene	6.4E-09		2.9E-05		4.2E-06	3.4E-05	6
Benz[a]anthracene	5.0E-07		8.1E-07		3.8E-07	1.7E-06	114
Benzo[a]pyrene	3.8E-07		7.9E-06		1.3E-08	8.3E-06	23
Benzo[b]fluoranthene	8.8E-07		3.3E-08		1.7E-09	9.2E-07	210
Benzo[ghi]perylene	2.0E-07		1.7E-08		4.4E-09	2.2E-07	865
Benzo[k]fluoranthene	8.4E-07	2.5E-08	4.5E-08		2.3E-09	9.1E-07	212
Chrysene	7.1E-07		4.6E-07		7.1E-08	1.2E-06	155
Dibenz[a,h]anthracene	7.1E-07		8.9E-08		9.0E-10	8.0E-07	241
Fluoranthene	1.1E-07	5.2E-07	4.4E-07		8.7E-07	1.9E-06	99
Pyrene	9.0E-08	1.1E-08	1.1E-05		1.1E-06	1.3E-05	15
Carbendazim	8.0E-10	0.0E+00	1.3E-06		1.1E-13	1.3E-06	150
Chlorpyrifos	7.3E-09	3.1E-07	1.1E-08	1.1E-07	2.7E-06	3.2E-06	61
Cypermethrin	5.1E-08	9.6E-08	1.7E-07		5.1E-09	3.2E-07	599
Diffufenican	4.3E-09		4.4E-09		2.2E-08	3.1E-08	6182
Diuron	3.2E-10	1.8E-07	3.5E-09		4.4E-11	1.9E-07	1029
Imidacloprid	4.8E-10		1.5E-05		1.5E-16	1.5E-05	13
Pentachlorophenol	7.6E-09		1.3E-05		3.0E-09	1.3E-05	15
Diclofenac	3.4E-10	8.3E-08	2.8E-05	1.2E-08	3.8E-13	2.8E-05	7
Estradiol	1.3E-08		5.5E-06		2.6E-12	5.5E-06	35
Estrone	3.9E-09		3.7E-06		2.3E-11	3.7E-06	52
Ibuprofen	4.6E-09	8.2E-07	2.2E-07	2.3E-07	2.1E-08	1.3E-06	148

# Does it pay off to have fate models?

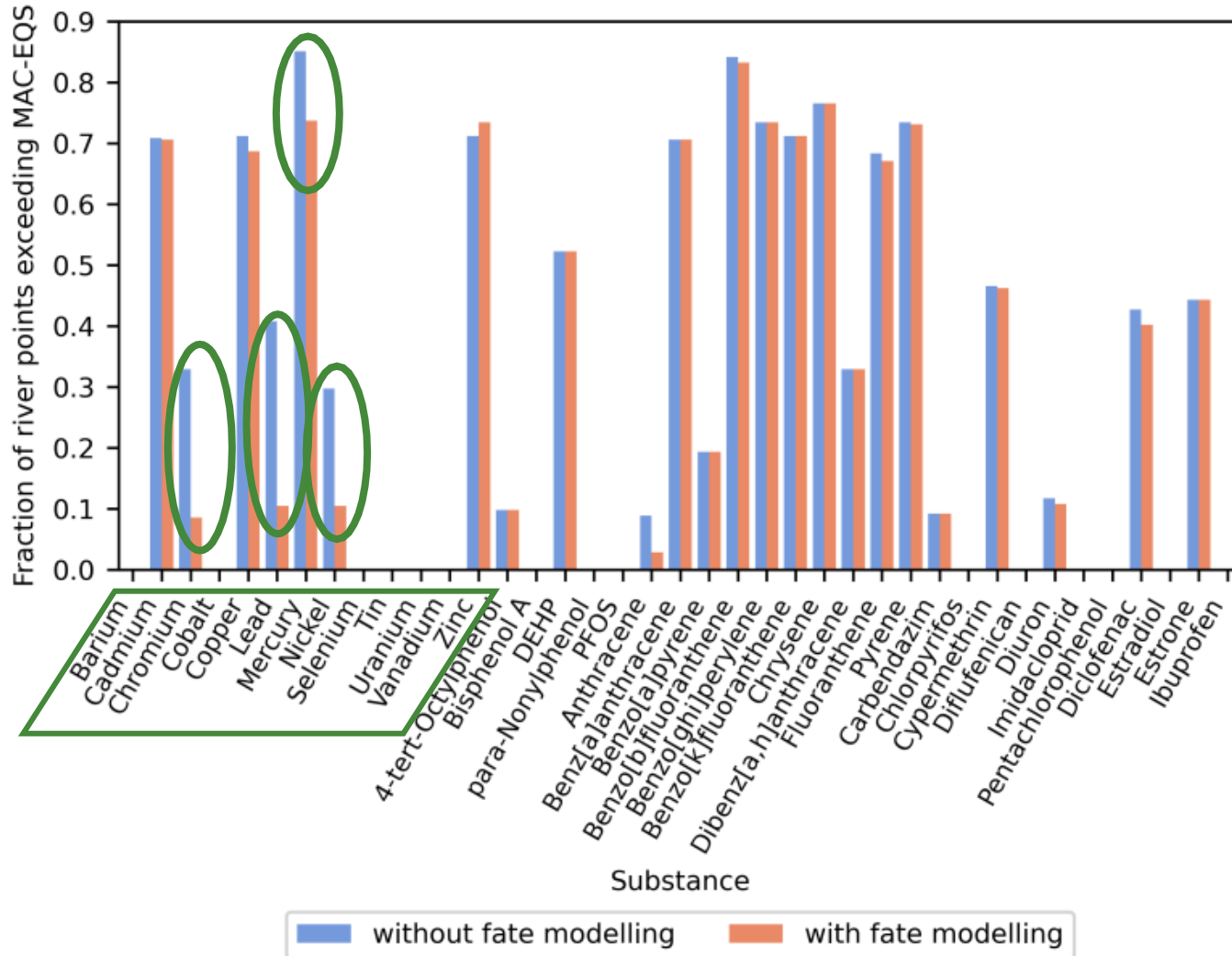


- Fate model vs simple dilution model ( $k=0$ )
- Calculation of fraction of river points where

$$RQ = c/EQS > 1$$

How many of the river nodes are above Environmental Quality Standard (EQS)?

# Does fate model matter?

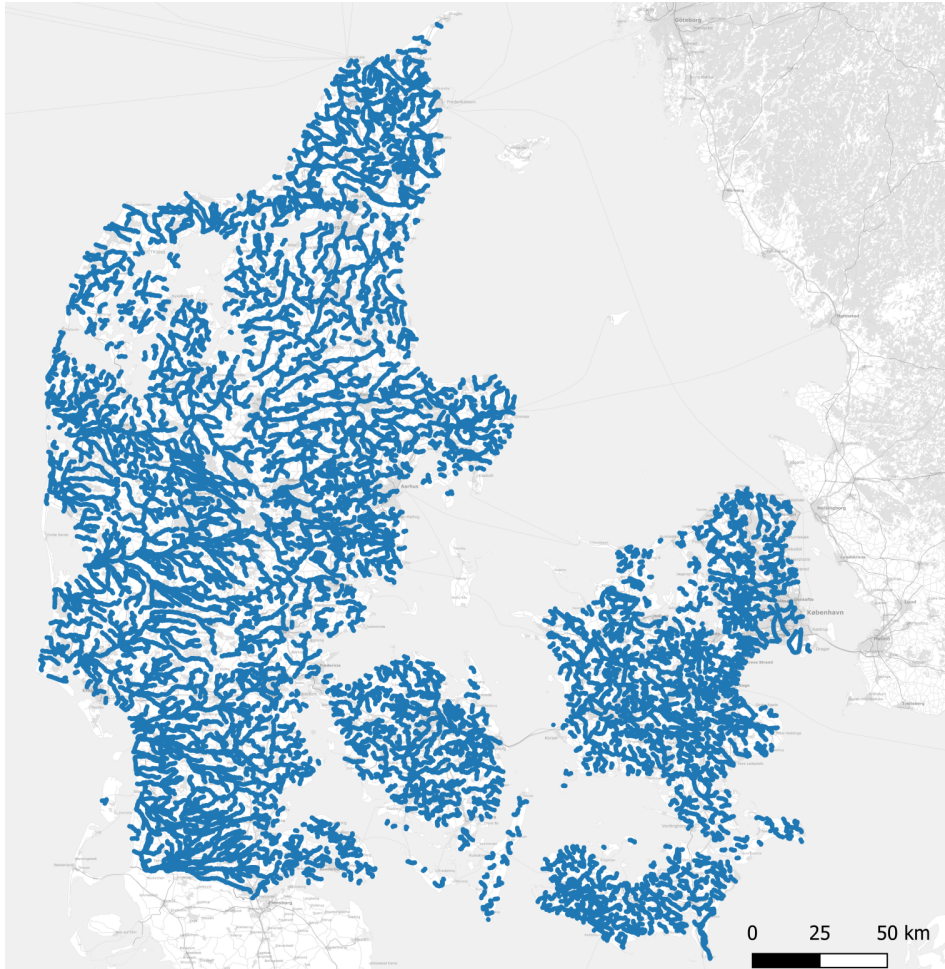


- Heavy metals: EQS based on bioavailable (= dissolved) concentration
- Fate model allows to calculate risk quotients from dissolved concentrations



- Removal is not relevant, but partitioning!

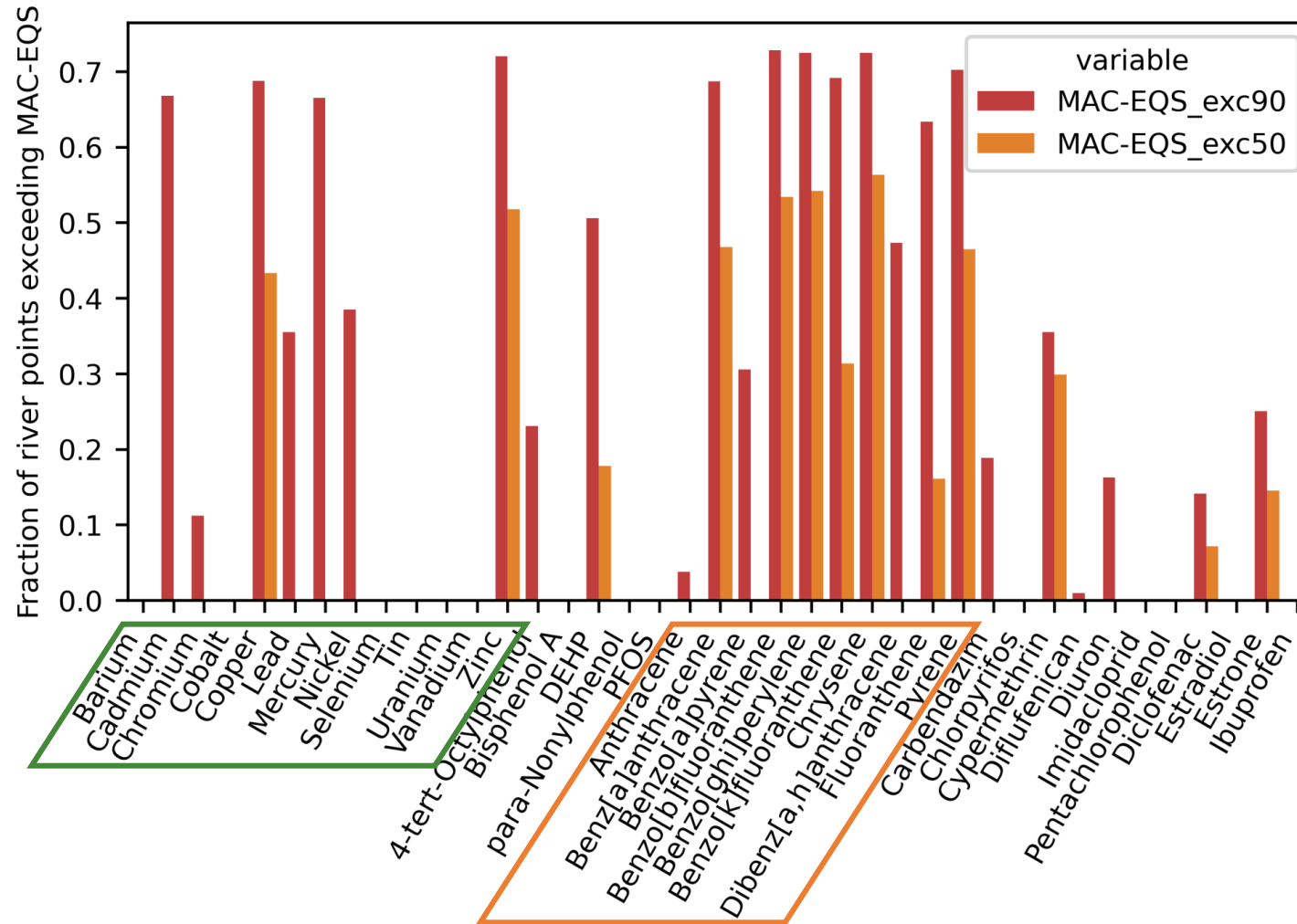
# How are the Danish rivers doing?



- 1.791 rivers receiving wet-weather discharges
- 33.719 modelled river points
- River flows in July (lowest flow)
- 2.686 CSOs, 11.580 SWOs
- Archetype storm event with return period of 0.5 yrs
- Discharge concentrations from 50% and 90% of literature distributions



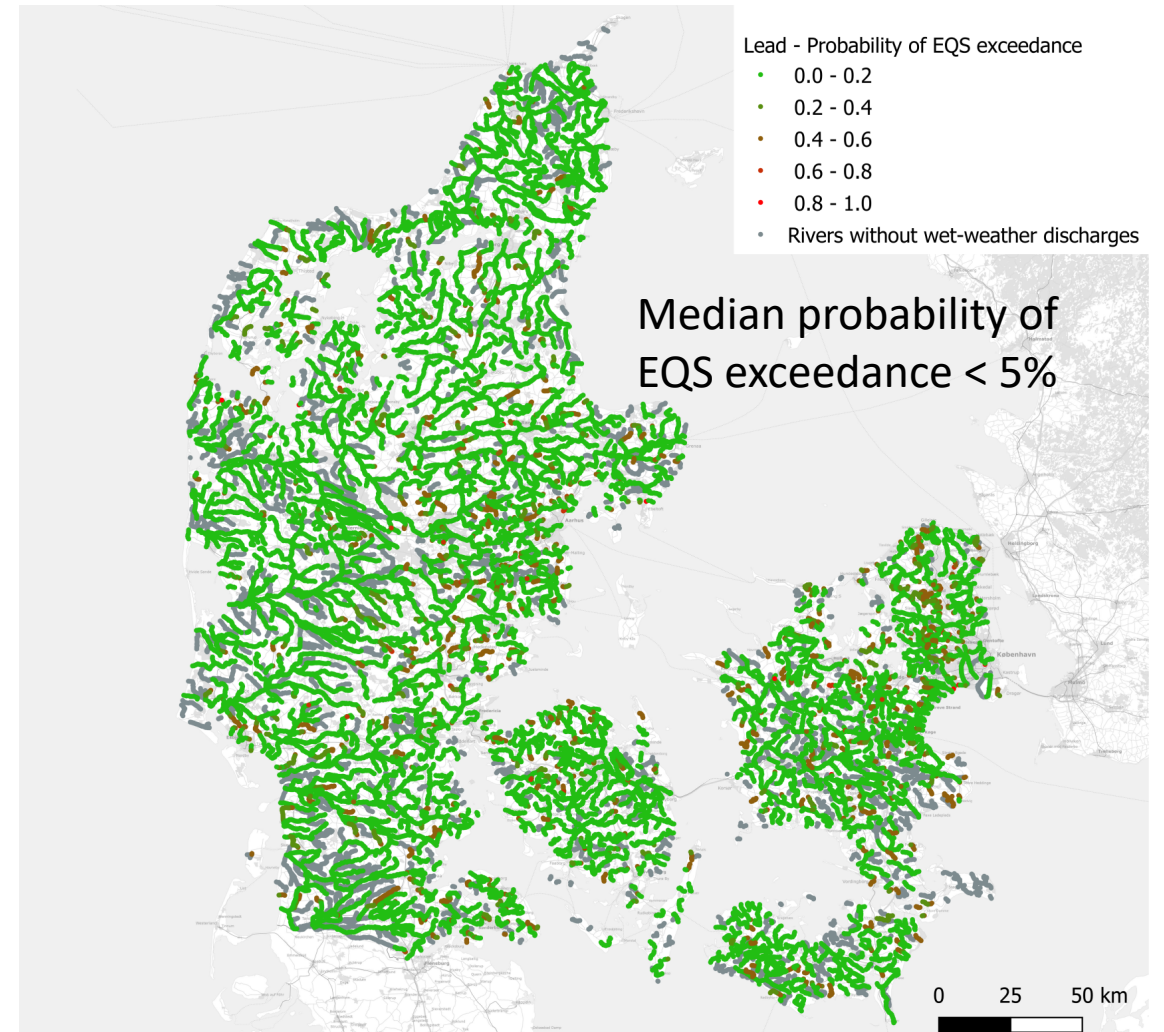
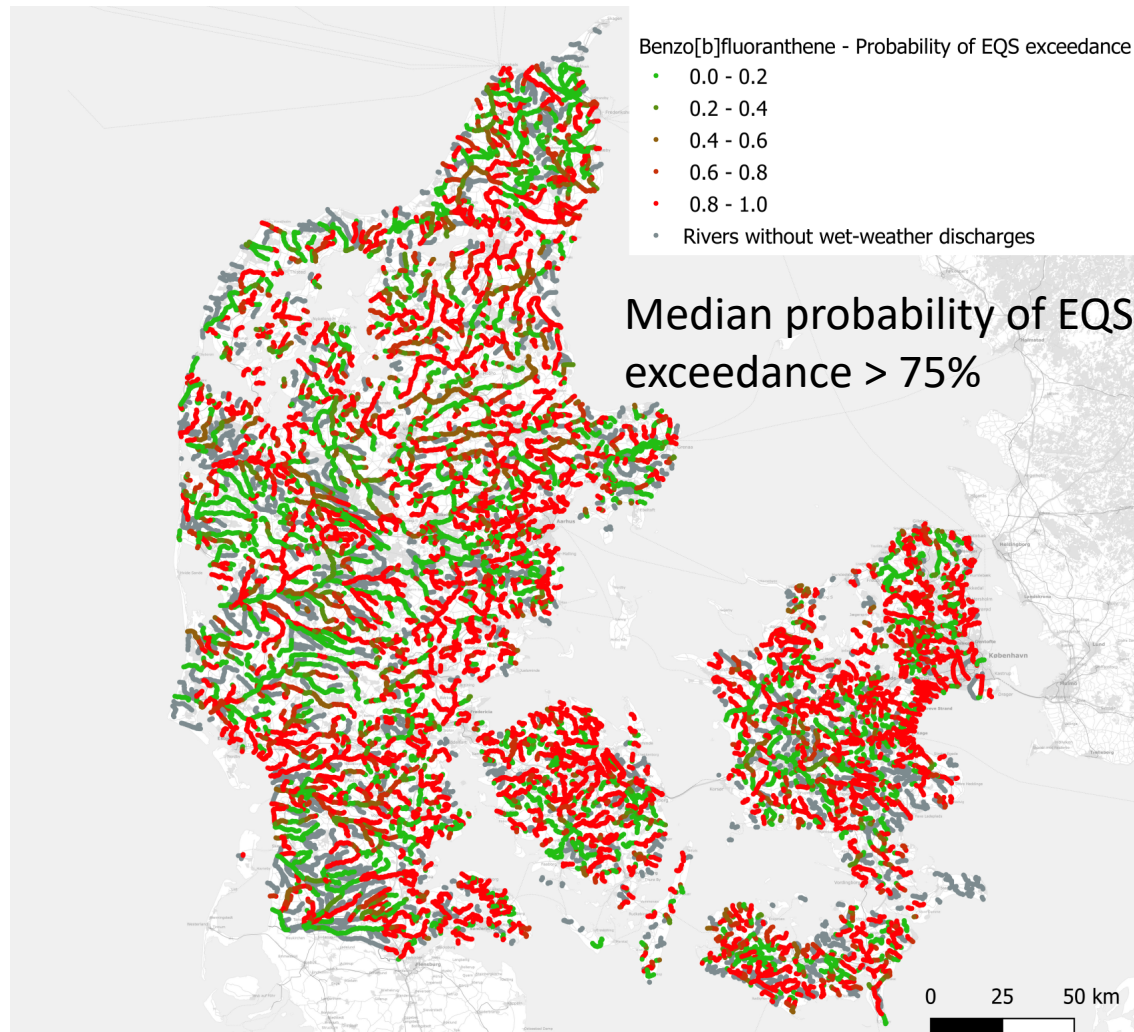
# How are the Danish rivers doing?



- Not that well
  - Especially for heavy metals and PAHs
- For several substances over 40-50% of river points exceeds EQS

# How much can we trust this model?

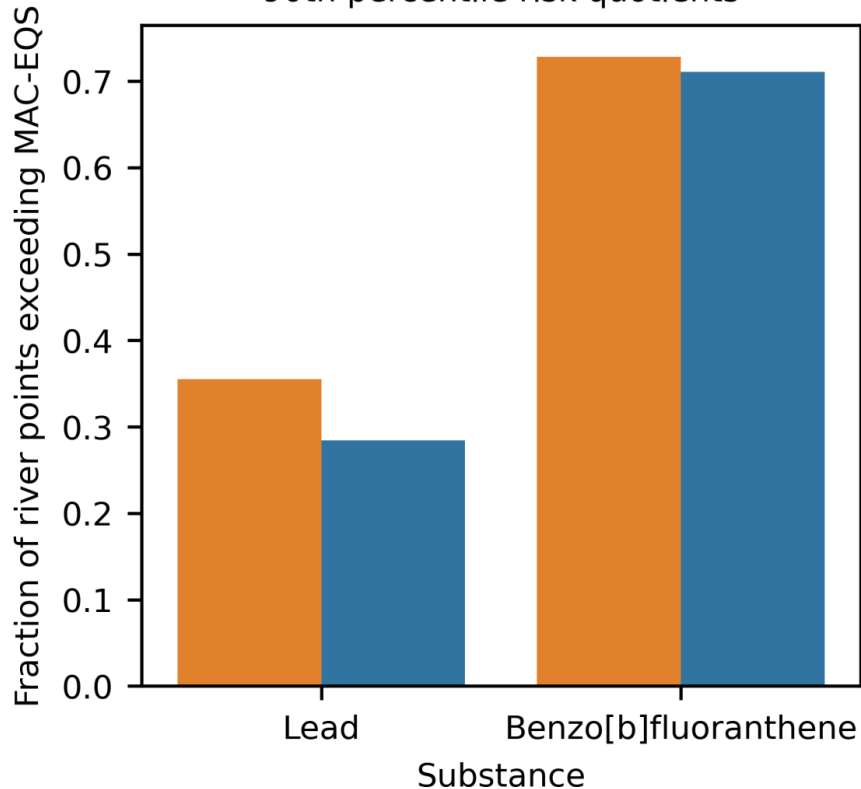
- Result of Monte Carlo simulations (1.000 runs)



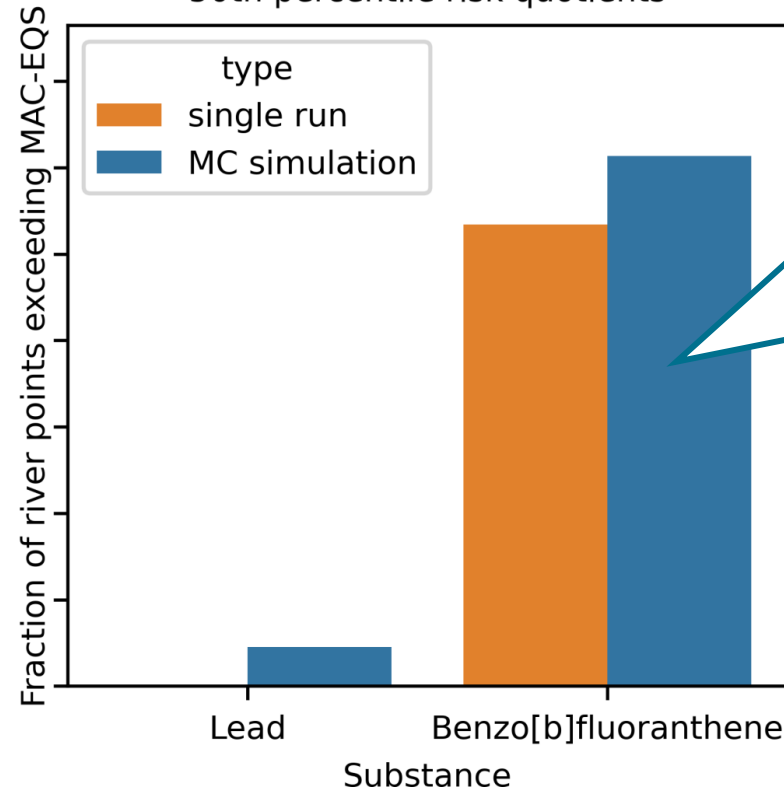
# How much can we trust this model?

- Monte Carlo simulations (1.000 runs) vs. one simulation (with fixed percentiles)

Comparison of EQS exceedance from single model run and Monte Carlo simulations  
90th percentile risk quotients



50th percentile risk quotients



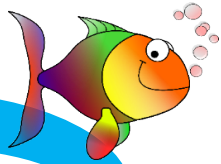
Well, no need to run a lot of simulations then...

# Conclusions



- Simple screening tool now available to assess potential impacts from WWD discharges

Can quickly find out if discharge can cause an environmental risk or not



or



- Identify streams with potential risk need which need more detailed modelling/monitoring

## Future steps

- Potential coupling with monitoring/reporting systems (near real-time risk assessment?)
- Look into toxicity mixtures?
- A tool for the whole Europe?