Complex water quality simulations in Želivka river basin and Švihov water reservoir

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CzechGlobe, v.v.i. (Global change research institute, Brno, CZ):
project leader, data aquisition, field measurement, modelling, service provider

DHI a.s. (Prague, CZ): modelling, software and knowledge transfer, tools developer

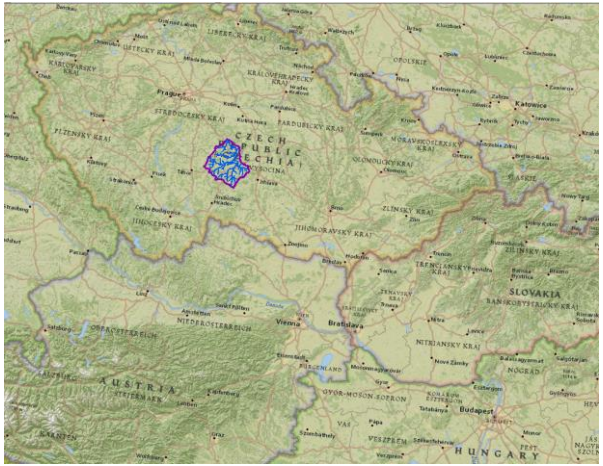
Povodí Vltavy s.p. (Vltava river basin authority, Prague, CZ):
data collection, final user

VÚMOP v.v.i. (Research Institute for Soil and Water Conservation, Prague, CZ):
research data, field measurement, knowledge transfer

Work is supported by projects Trans-Adapt and Adapt-Želivka (leader: CzechGlobe)

Complex water quality simulations in Želivka river basin and Švihov water reservoir

Overall aim: preserving sustainable water quality in reservoir for future use with reasonably minimized impact to river basin area inhabitants, agriculture and other activities



Focus:

A) Scenarios of pollution distribution and transport in vater volume of reservoir

B) Nutrients balance and estimation of input into reservoir from river basin area

C) Pesticides leaching and transport processes during events in catchments, along streams and in reservoir

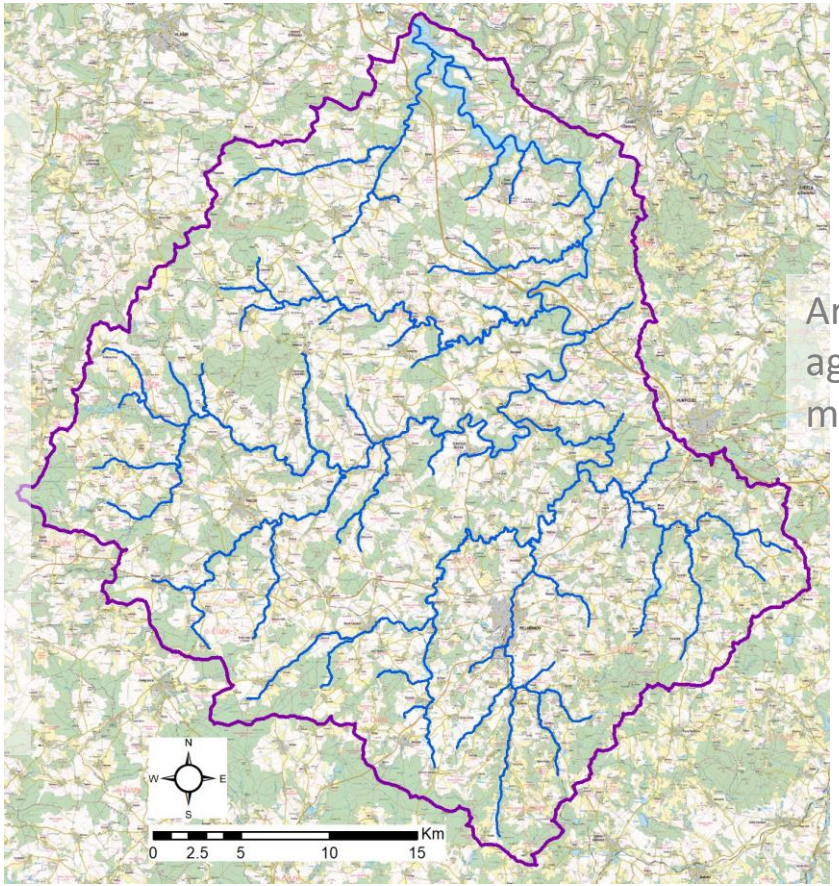
Želivka river basin

Total area: 1178 km^2
Hilly landscape
(315-765 m a.s.l.)

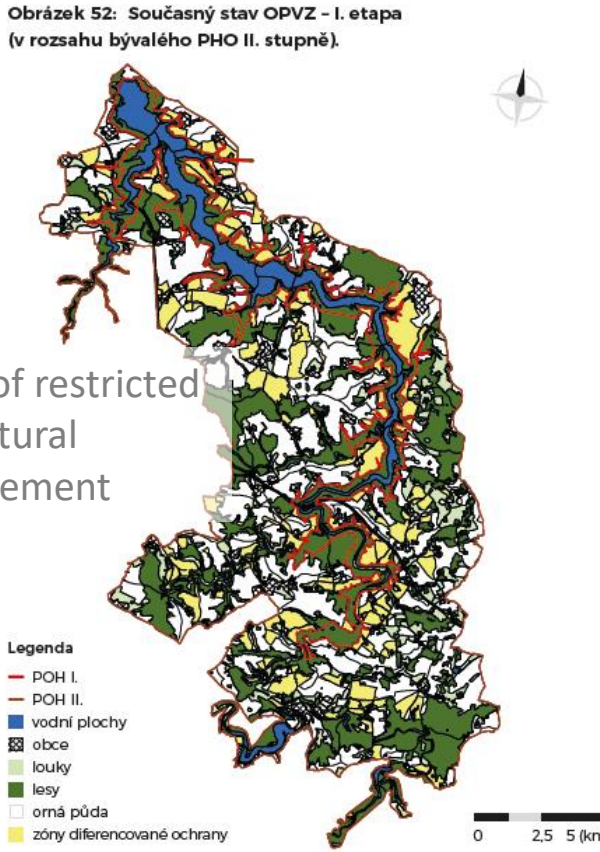
Arable: 51%
Forests: 30%
Green areas: 16%

Dystric Cambisol
Crystalline bedrock

1 town Pelhřimov
(approx 16 000 inh.)



Areas of restricted agricultural management



Source: Kvítek T. (ed.) Retence a jakost v povodí vodárenské nádrže Švihov na Želivce

Švihov water reservoir

The largest reservoir for drinking water in CZ (CEE)

Source of water for Prague

via tunnel 51 km long

Water level area 16 km^2

Volume 309 mil. m^3

Max. depth 50m

bottom outlet, take-off for water treatment plant in variant depths,

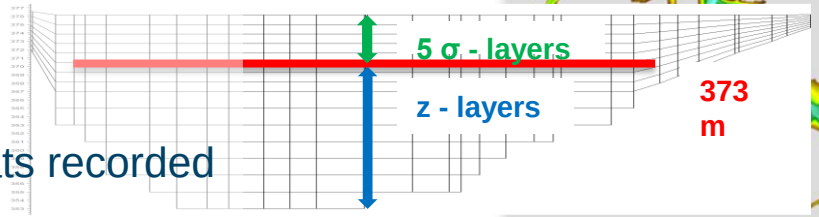
3 functional bridges (3 defunct.)

picture: Povodí Vltavy

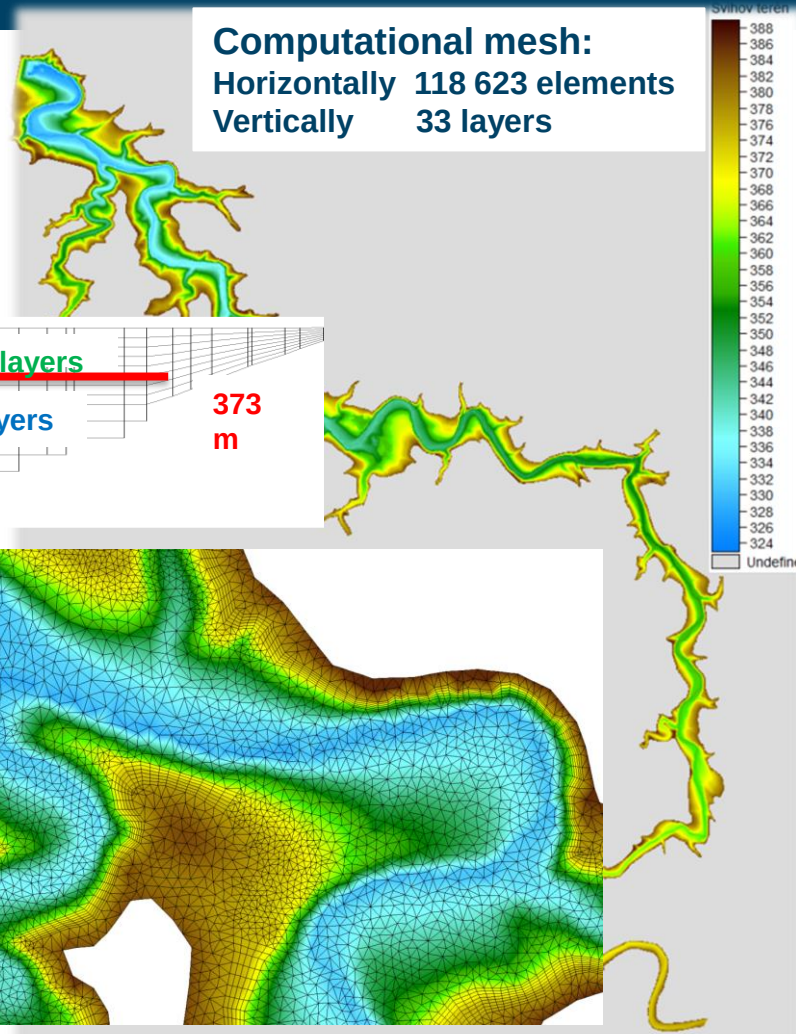
3D model of Švihov water reservoir

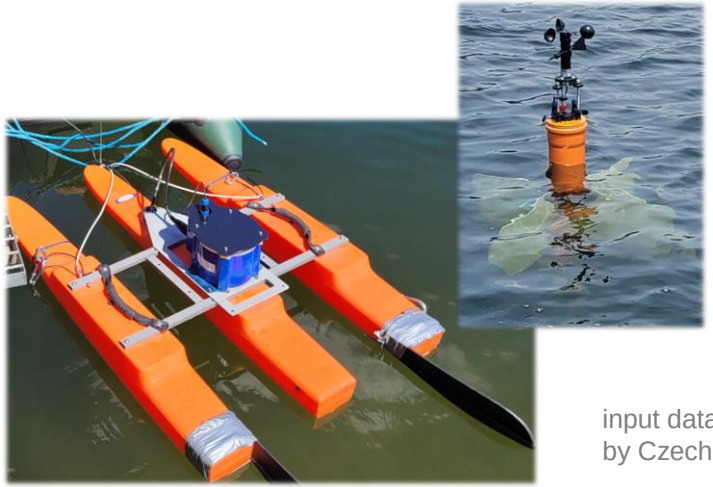
MIKE3 FM + ECOLAB

Meteodata and hydrologic data collected
(incl. distributed wind fields)
water temperature distribution,
flow velocity by ADCP and floats recorded



Computational mesh:
Horizontally 118 623 elements
Vertically 33 layers

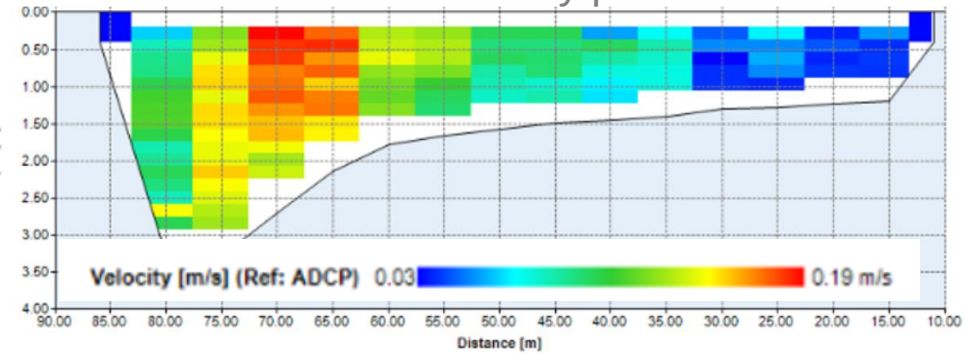


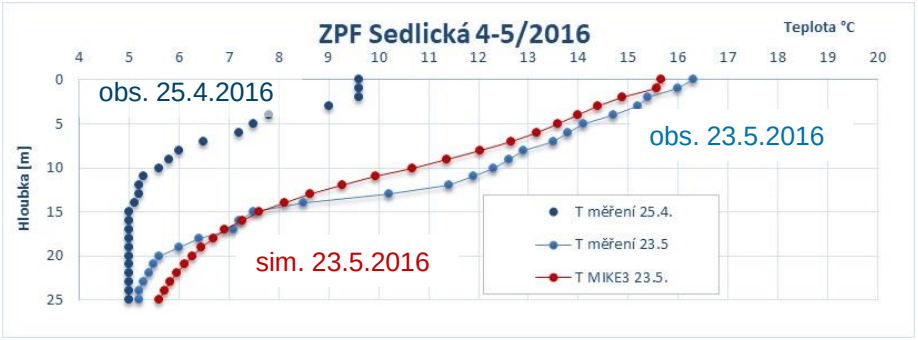


input data provided
by CzechGlobe

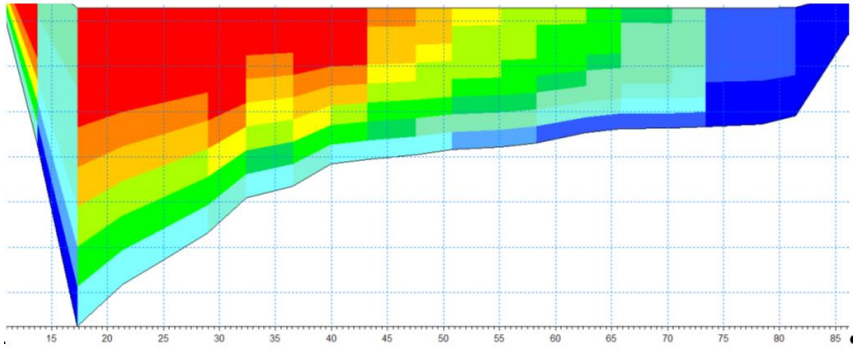
Calibration against flow velocity profiles and measured temperature profiles

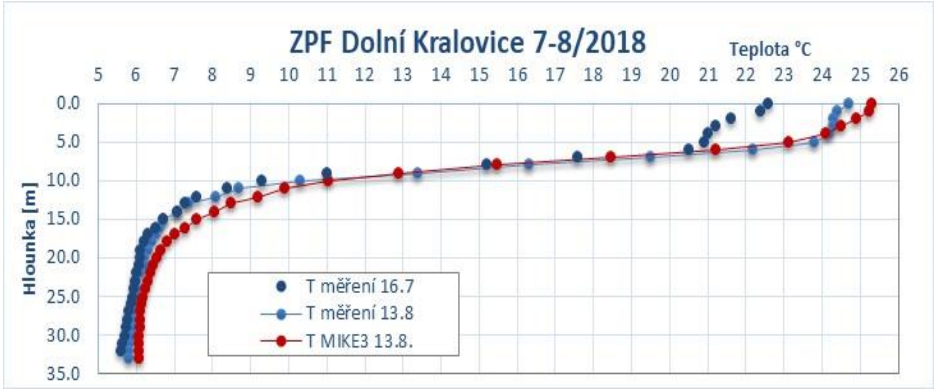
ADCP recorded velocity profile





MIKE 3 FM simulated velocity profile

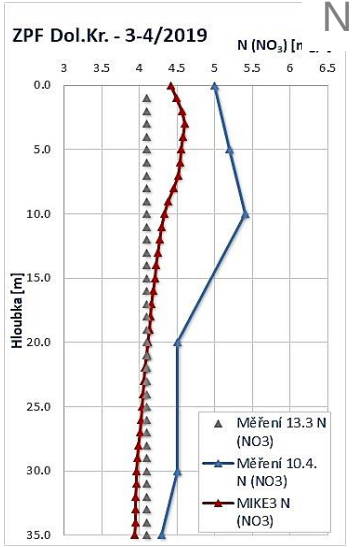


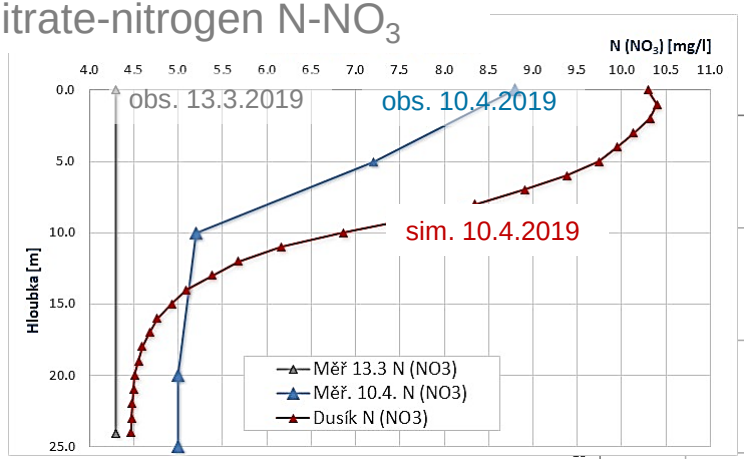


observed data provided by CzechGlobe and Povodí Vltavy

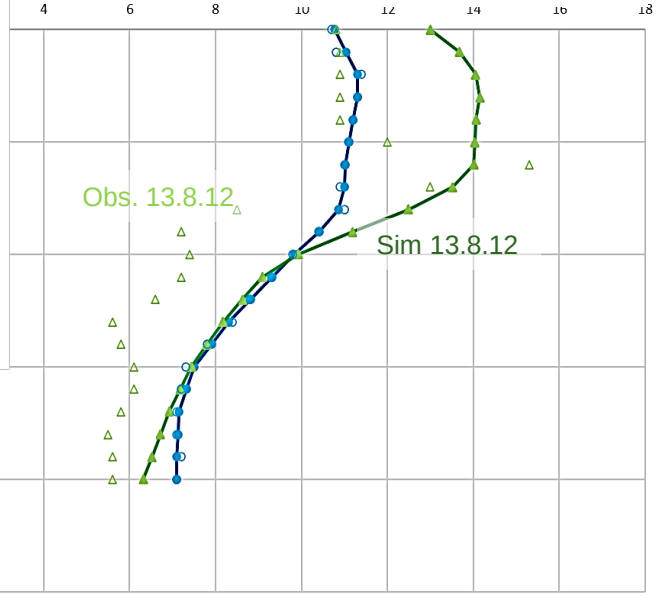
Simulation of P and NO_3 transport and dissolved oxygen distribution (MIKE 3 + AD/ECOLAB)

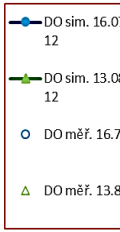
Nitrate-nitrogen N-NO_3



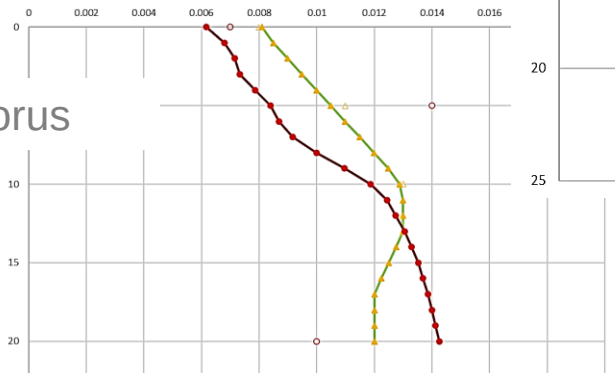


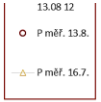
Dissolved oxygen





Tot. phosphorus





observed data provided by Povodí Vltavy

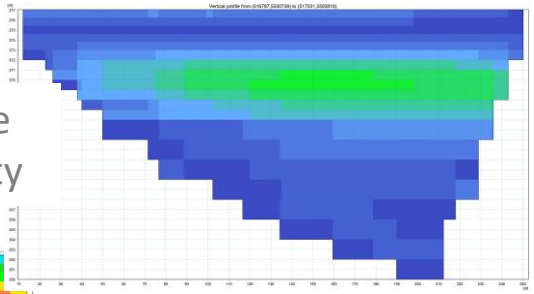
Simulation of scenarios

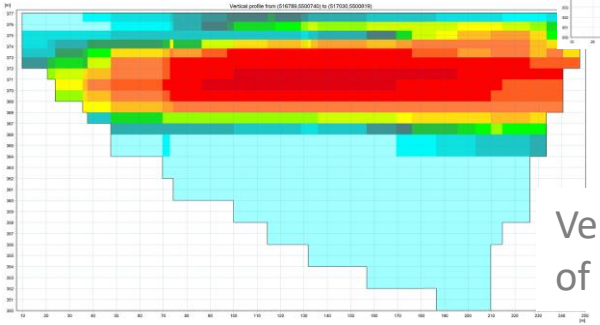
Combinations of reservoir water level, wind, discharge, season and water intake discharge

+

Variants of locations (point / tributary) and type of pollution (temperature / conservative)

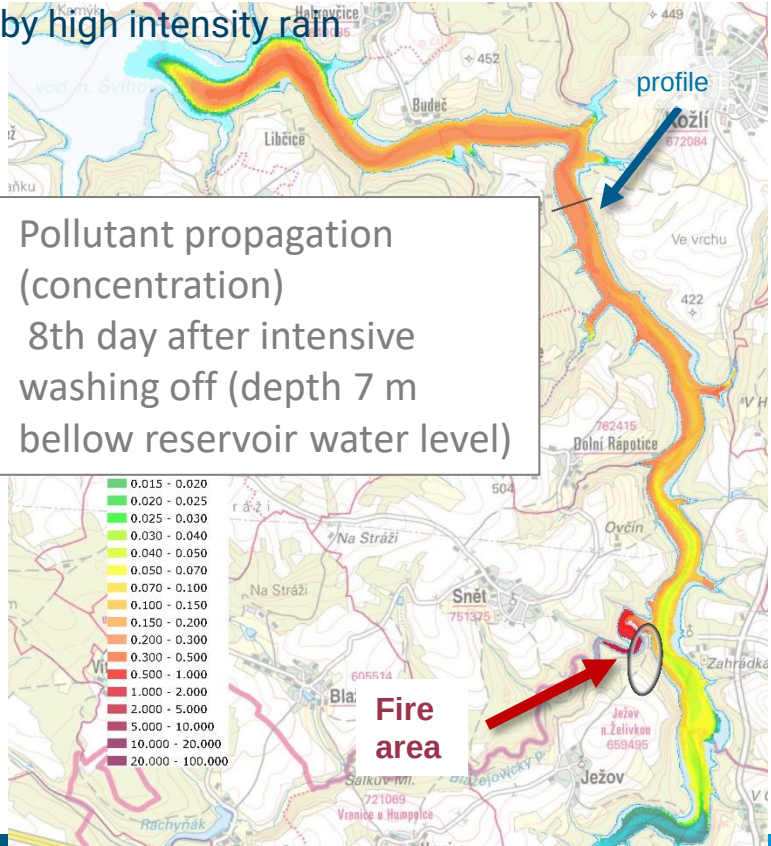
Vertical profile of flow velocity





Vertical profile of concentration

Scenario **3**: High Q, full reservoir, summer temperature stratification
Pollutant – the product of the forest fire is washed away by high intensity rain



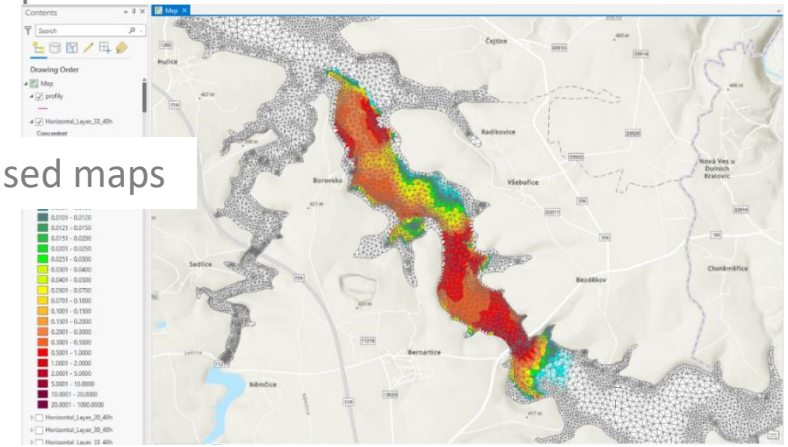
Pollutant propagation (concentration)
8th day after intensive washing off (depth 7 m bellow reservoir water level)

A tool for decision suport in case of pollution events

- Simplified 3D model of flow and transport derived
- Model ready for fast short-term forecast purposes
- Automated chain of processes:
  - data collection
  - pre-processing
  - model simulation
  - results presentation
- Specific user interface created (independent from model code and common DHI software)

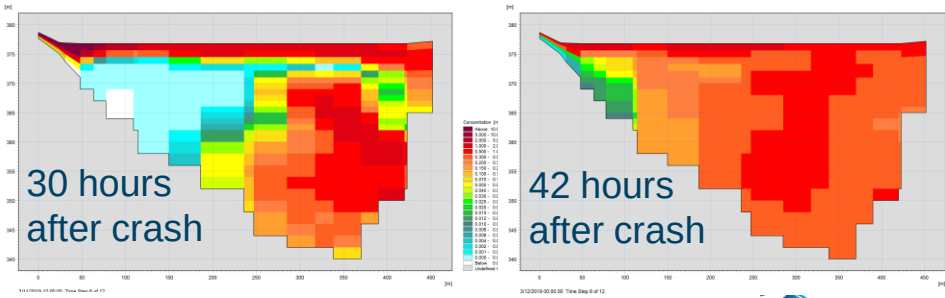
Examples of user interface:

GIS-based maps



Pre-defined tabular outputs

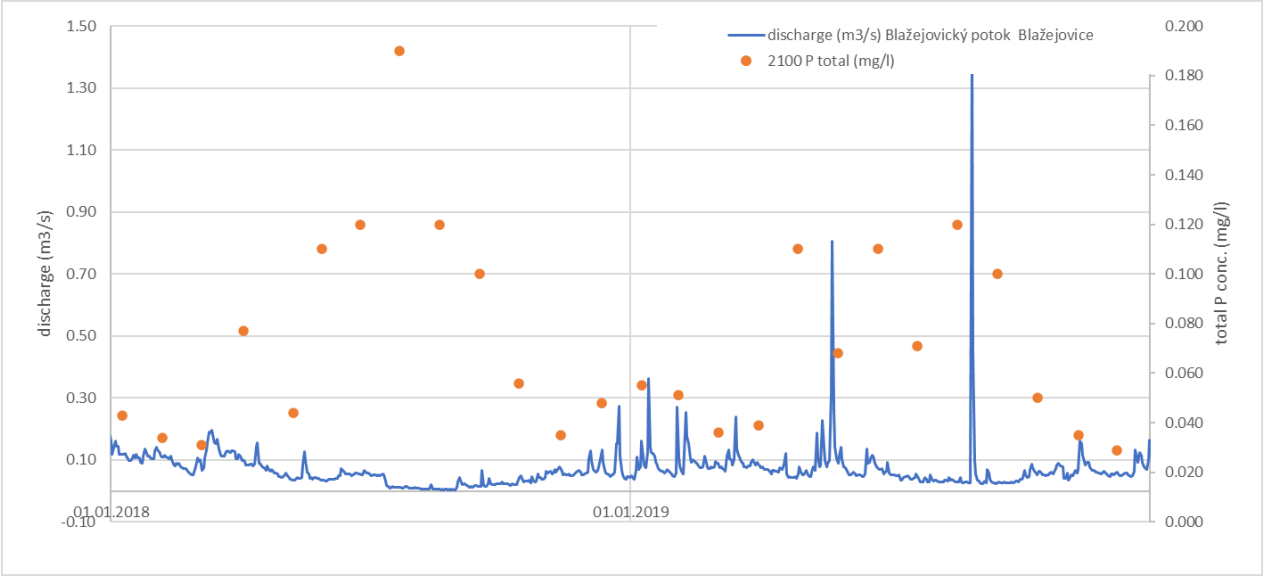
	A	B	C	D
1		Concentration Non Dim[(]):Instantaneous	Concentration Non Dim[(]):Instantaneous	Concentration Non Dim[(]):Instantaneous
2		layer_30: Concentration - component 1	layer_29: Concentration - component 1	layer_28: Concentration - component 1
3	3/10/2019 0:00	0	0	0
4	3/10/2019 6:00	0	0	0
5	3/10/2019 12:00	3.738137007	4.937469959	5.763155937
6	3/10/2019 18:00	5.191720963	4.149943352	5.641005516
7	3/11/2019 0:00	1.737227201	0.942106545	2.268623114
8	3/11/2019 6:00	1.150508285	1.107563496	1.316570282
9	3/11/2019 12:00	0.624020875	1.35250926	1.676476598
10	3/11/2019 18:00	0.871532083	0.76623261	0.874272287
11	3/12/2019 0:00	2.419434547	2.482123137	2.519948483
12	3/12/2019 6:00	2.306411505	2.502052307	2.394864082
13	3/12/2019 12:00	1.723915696	1.588498116	1.514489293
14	3/12/2019 18:00	1.019806504	0.798297822	0.935654461
15	3/13/2019 0:00	0.58436805	0.481624275	0.530765474



Vertical profiles

Simple water balance and nutrient flux calculation

- data discharge records (daily average), discrete sampled nutrients concentrations and annual/monthly point sources data

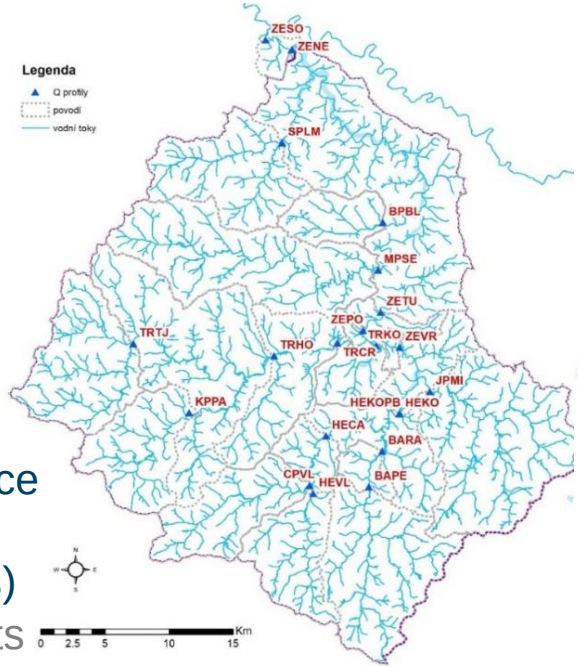


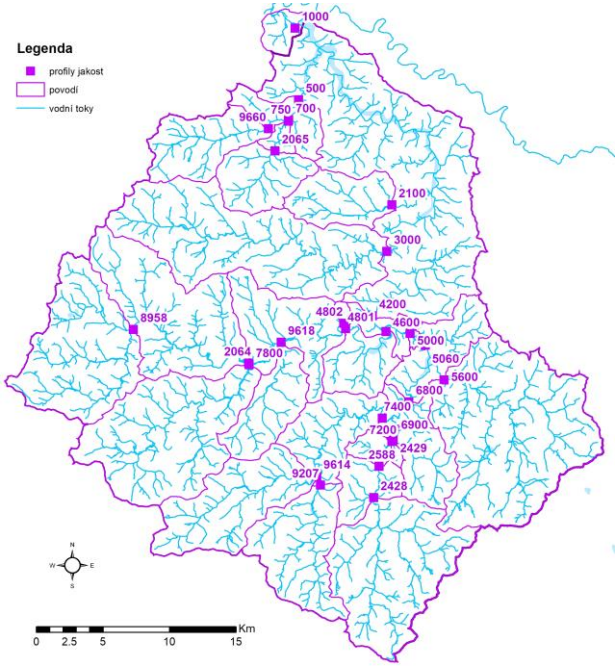
- 6 matters balanced: P total, N total, $N\text{-}NH_4$, $N\text{-}NO_3$, COD, BOD for **2015-2021** period
- results: simulated average mothly discharge, average monthly matter fluxes (concentrations) for current status (2015-2021) in whole river network

River basin, river network, data sources

18 discharge gauges (Povodí Vltavy), 27 water quality sampling points (Povodí Vltavy)

area 1178 km^2
100 point sources
11 water users
3 small water reservoirs





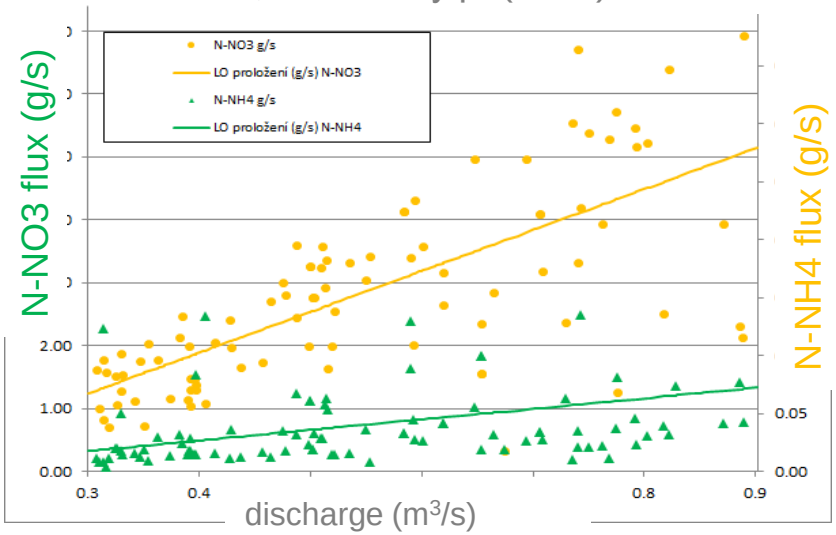
MIKE BASIN: simple water balance and WQ model (1st order decay along river reaches)

159 computational sub-catchments
447 river reaches (total lenght 539 km)

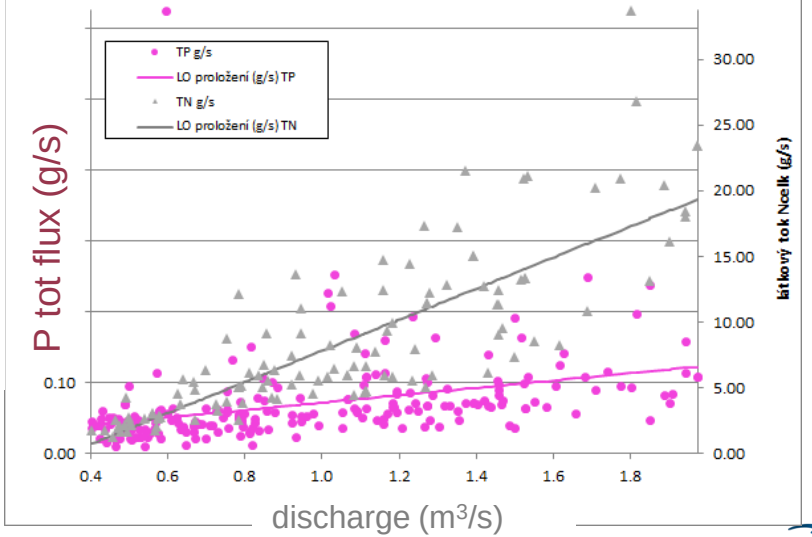
Method

- Corelation between flux and dischrage in day of sampling
- 12 monthly median values of river discharge and concentrations in sampling points are used for calculation of runoff and flux catchments and river reaches

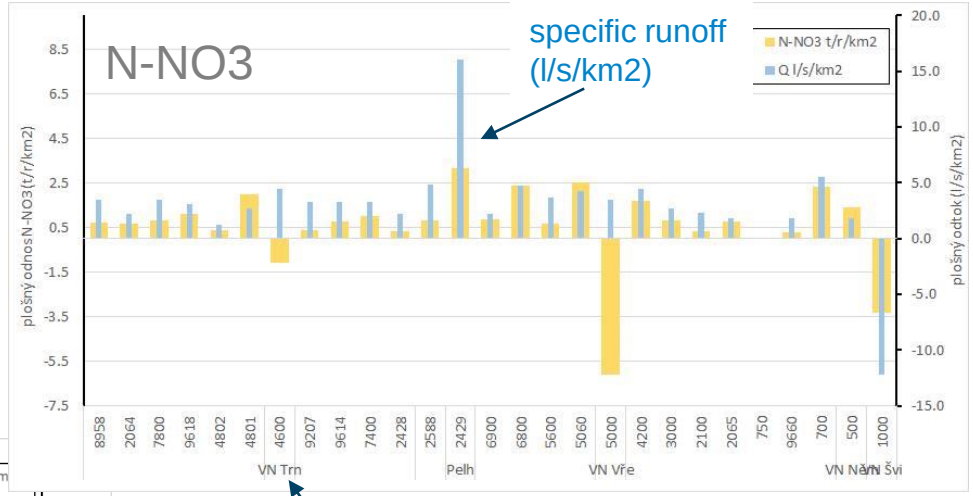
nitrate nitrogen, nitrate ammonia,
Kletečná, Jankovský p. (5600)



total phosphorus, Červená Řečice (4801)



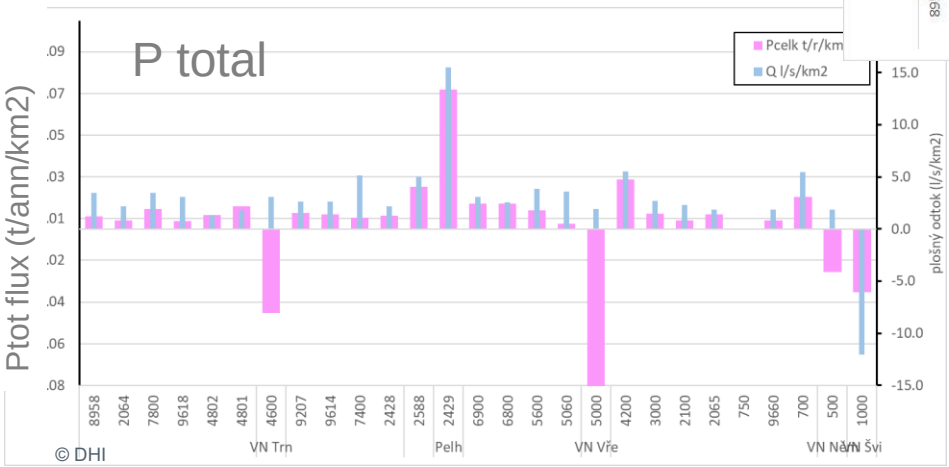
Anual flux balance for catchments



N-NO3 flux (t/ann/km2)

sampling points identificators

reservoirs denoted

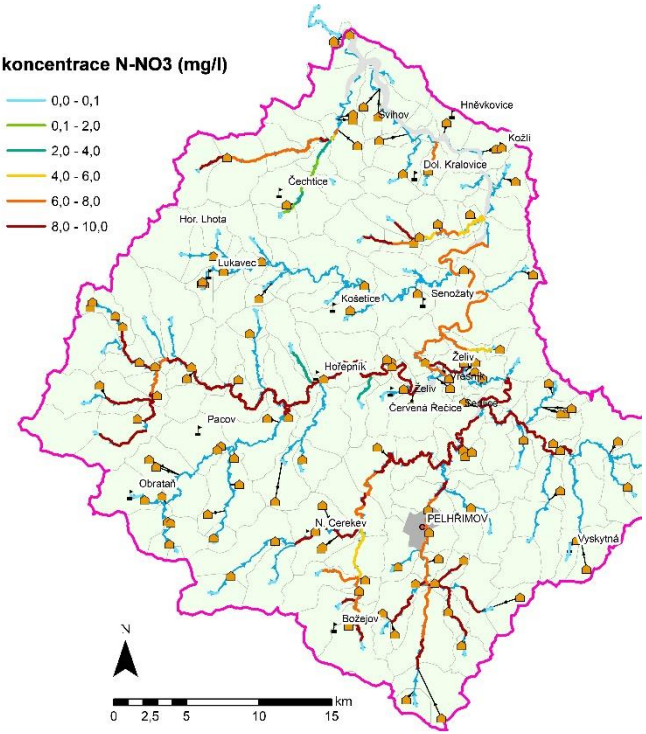


Ptot flux (t/ann/km2)

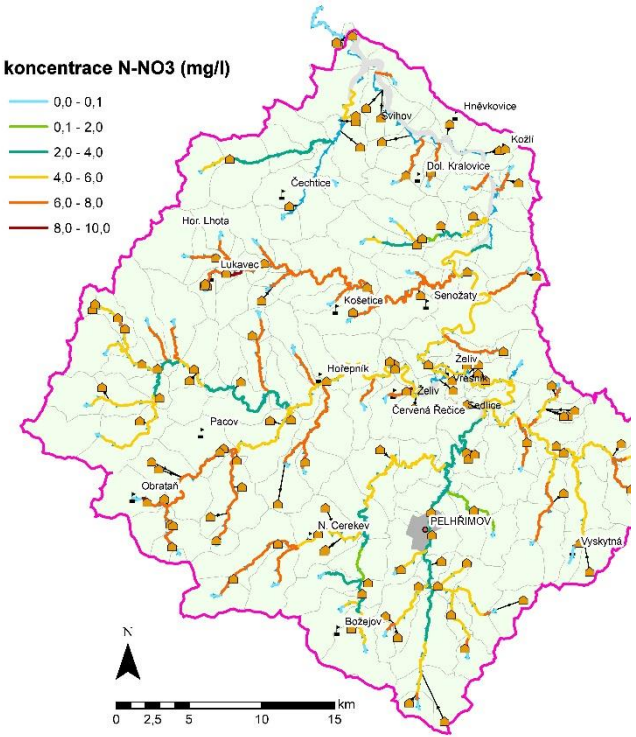
Concentrations in river network

example: simulated N-NO3 concentrations (mg/l) along river network

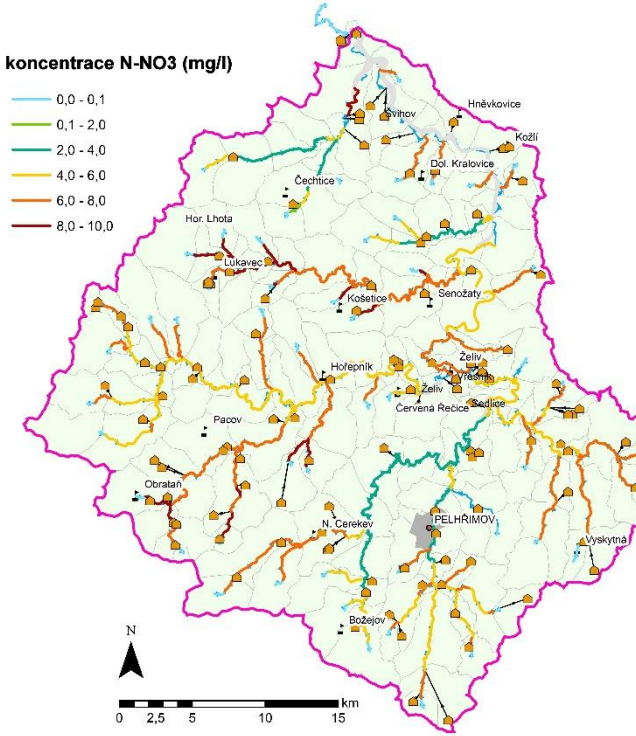
March



August



November



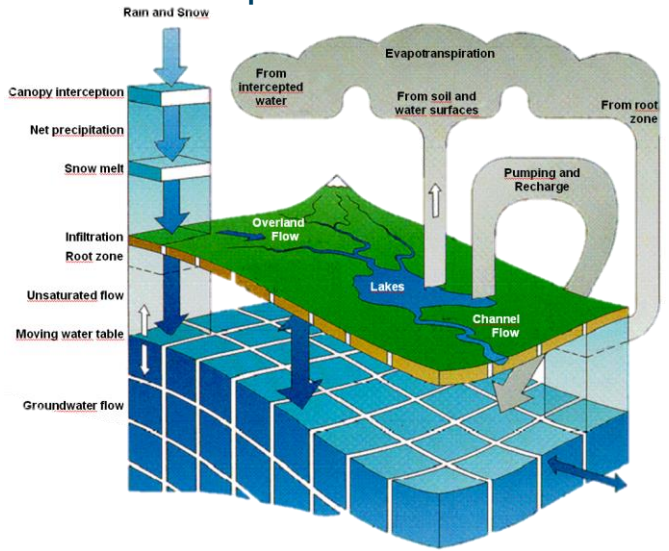
Detailed distributed hydrological and water quality modelling in catchments

Aims

- understanding of pathways of different kind of pesticides detected in water courses
- simulation of future conditions impact to water quantity and quality
- Simulation of rapid land use change impact
- Tool for optimization of adaptation measures
- Background for reasonable measures settings and their impact assessment

Versatile modelling tools:

MIKE SHE WM +WQ + ECOLAB



Set of spatially distributed models

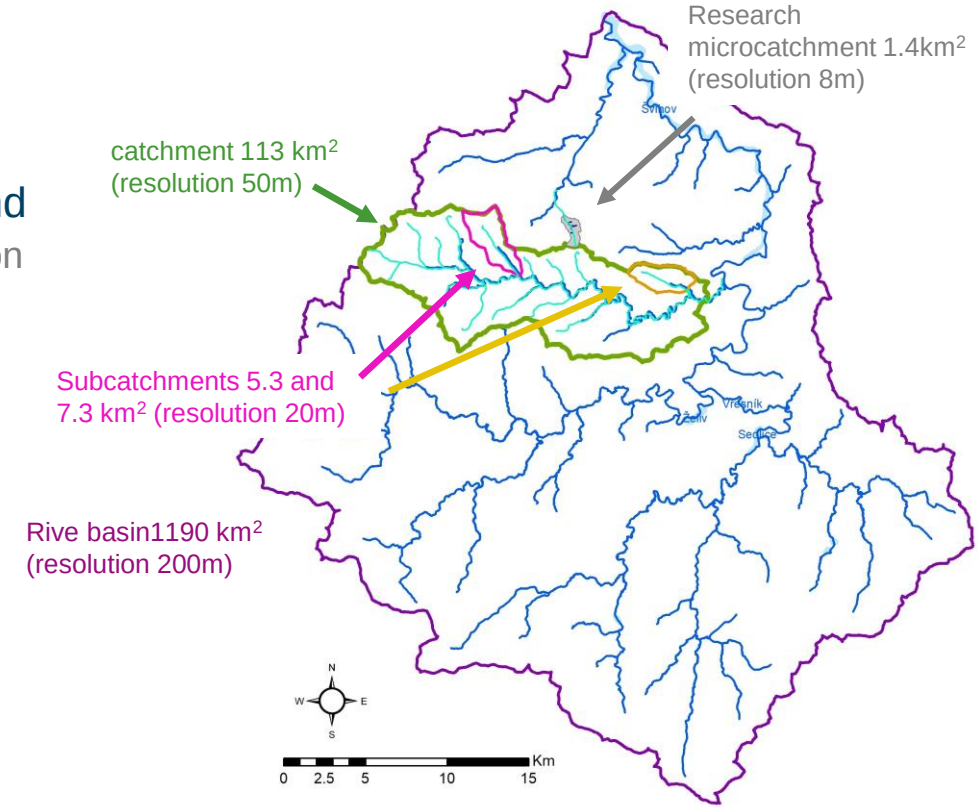
1. **Microcatchment** (research area): undestanding runoff formation and pesticide transport

1. 2 **sub-catchments** with standart inputs and various agricultural management: application of approach with limited inputs

2. **Catchment** of individual tributary to reservoir: generalisation to catchment scale

3. Whole **Želivka river basin area**: long-term full area scenarios

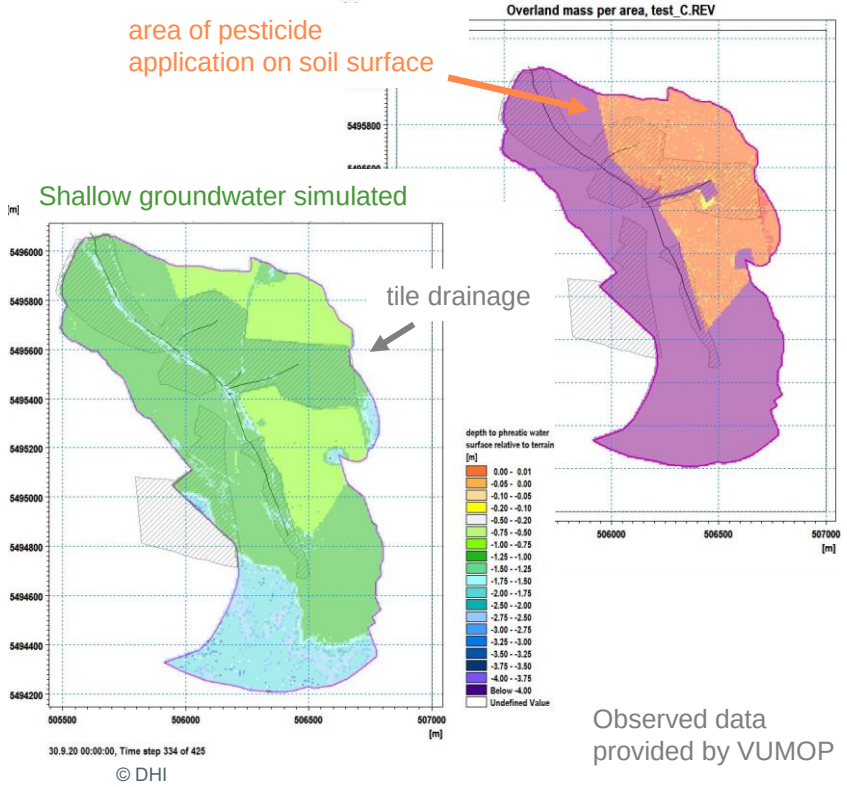
Fully distributed inputs and parameters,
Time series in 10min / 1h /1 day time step
Focus on runoff processes, stable water balance and transport (Advection-dispersion, 1st order decay + ECOLAB)



Detailed WQ data collected in frame of project „B4- Support of measures for decrease impact of agriculture in Želivka river basin)“

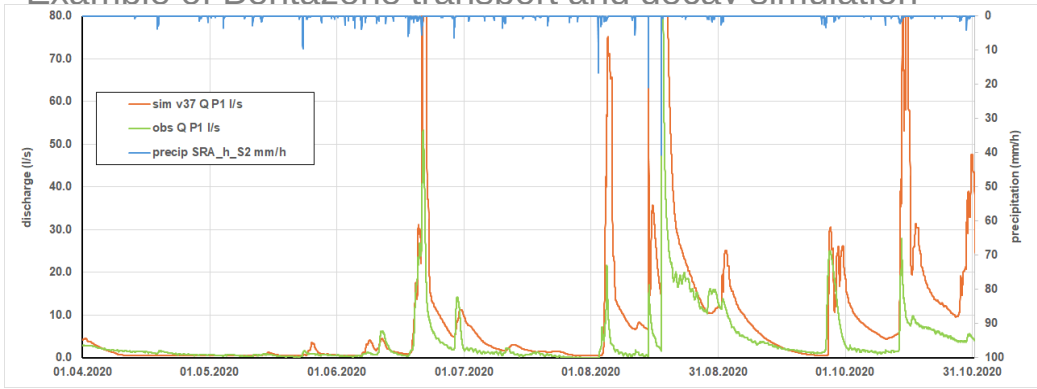
Hydrologic and WQ model of research microcatchment Černičí

1.4 km^2, Resolution 8x8m, time step 10/15min, simulated period 2018-2022

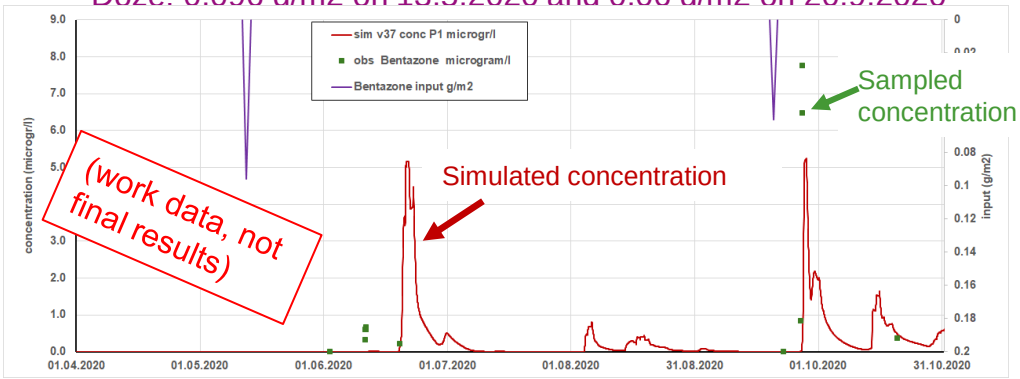


Observed data provided by VUMOP

Example of Bentazone transport and decay simulation

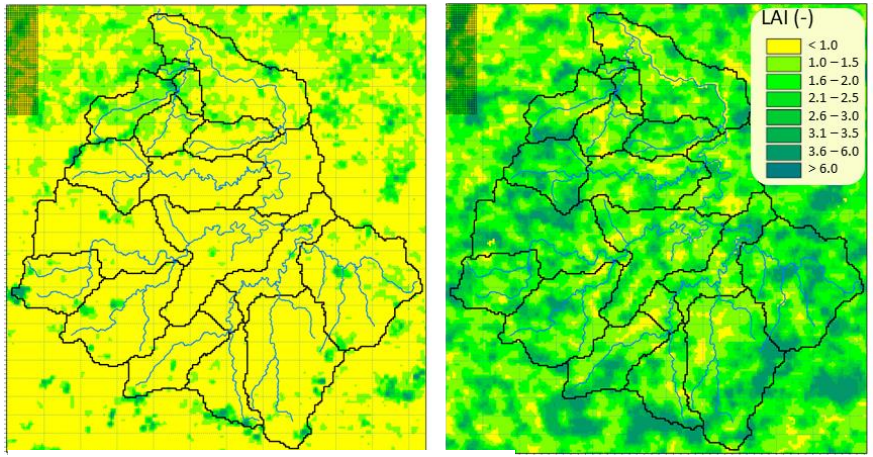


Doze: 0.096 g/m2 on 13.5.2020 and 0.06 g/m2 on 20.9.2020

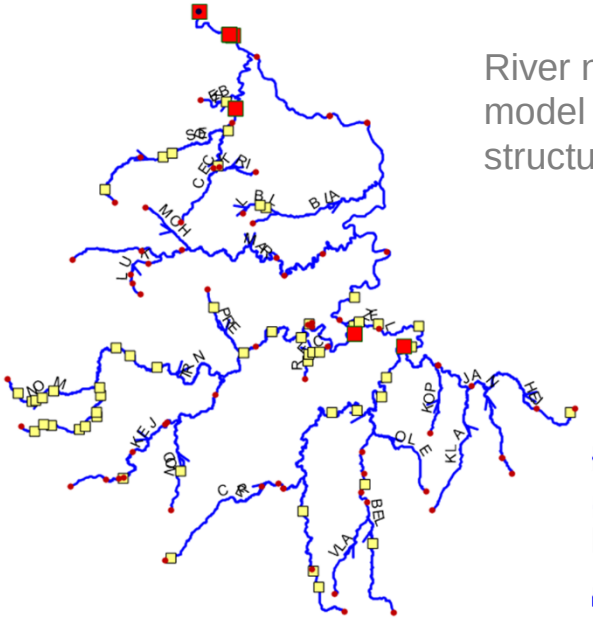


MIKE SHE hydrologic model of Želivka river basin

Resolution 200x200m, time step 1 day. Used for long-term climate impact simulations



Fully distributed inputs: LAI



River network model incl. structures

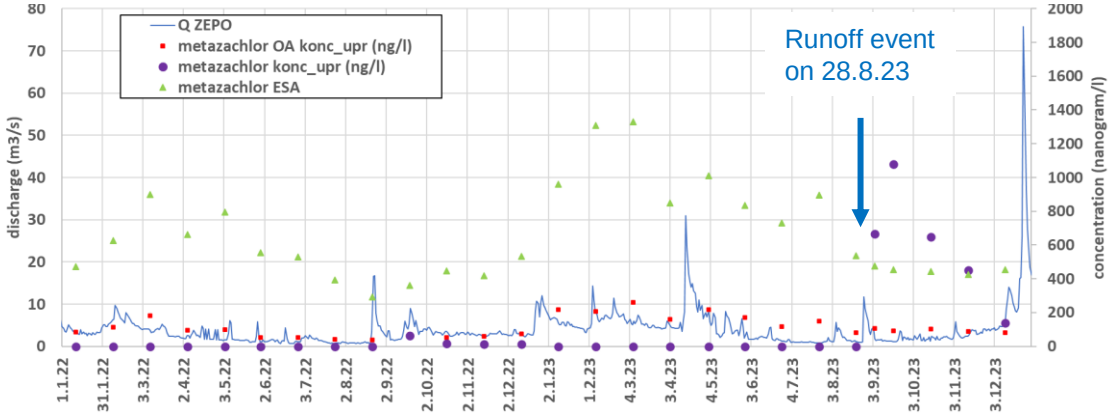
Upcoming steps: upscale transport processes to coarse resolution model

Hydrological model built by CzechGlobe

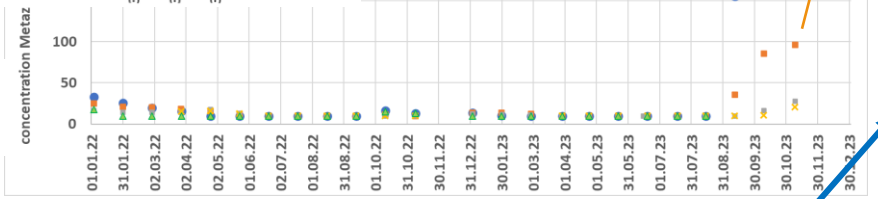
Complex approach is necessary

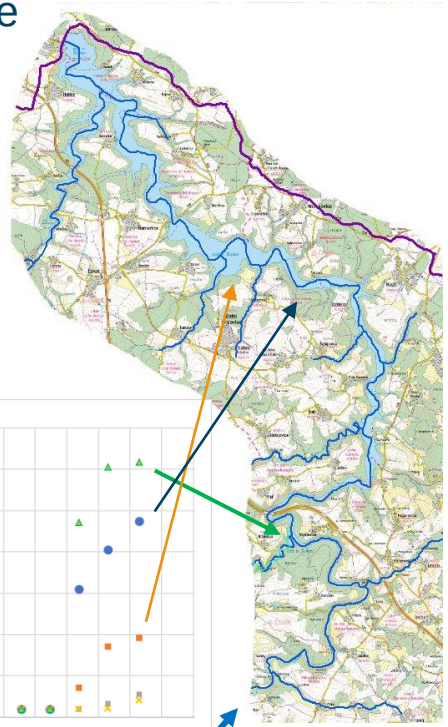
Real case: 8/2023 event - flush of notable amount of Metazachlor pesticide from part of river basin area

High concentrations indicated at some of water reservoir tributaries by regular monthly sampling after „common“ runoff event



High concentrations persisted in some parts of reservoir for several months





Data provided by Povodí Vltavy s.p.

Complex water quality simulations in Želivka river basin and Švihov water reservoir

Approach used: **interconnected modelling tools** for simulation of impact of various threads to water quantity and quality at river basin and Švihov water reservoir. These tools are based on up-to date knowledge and recent data available.

Result: Vltava river basin authority will receive a complex set of tools, knowledge and service for enhanced and timely **decision-making process.**

These tools support **adaptation** of management of this important water resource affected by **changing conditions**.

This will help keep **sustainable water quality** for drinking purposes for current time as well as for future.

Thank you for attention

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