

Climate Change and Water Quality in Želivka Basin

PHISHES test case in Czech republic

CzechGlobe & partners





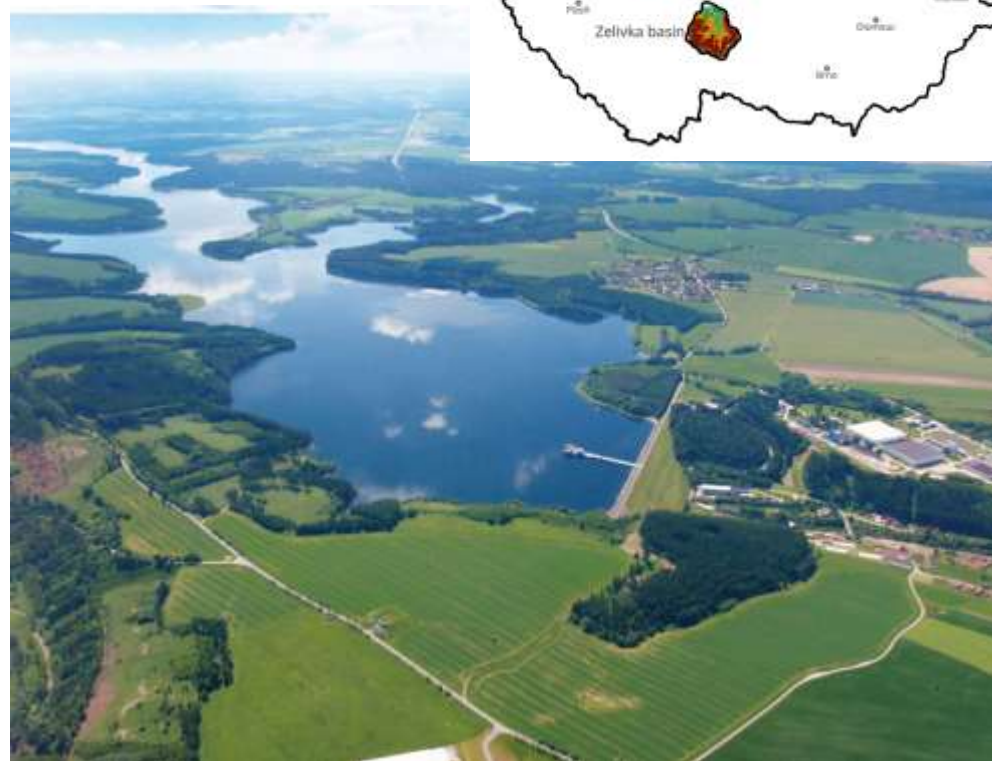
- 01 **Why Želivka basin?** — strategic drinking-water source and sensitive river basin
- 02 **What is the test site?** — basin characteristics, pressures and data coverage
- 03 **Why climate change matters?** — lower flows, less dilution, higher WQ vulnerability
- 04 **How we monitor?** — regular + event-based measurements
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- 06 **What we know so far?** — first operational models, preliminary findings and next steps



Why Želivka basin?

WHY IS THIS SITE STRATEGIC?

- Švihov is the **largest water-supply reservoir** in Czechia / Central Europe and supplies Prague and surrounding regions with drinking water (~1.5mil people)
- **Long-term pressures** come from **agricultural** sources (nitrates, pesticides and erosion-linked sediment transport) **and** from **settlements** (waste water treatment plants)
- The basin combines protected zones, arable land, forests, settlements (with and without water treatment plants) and pre-reservoirs; **water quality is therefore a whole-basin issue**

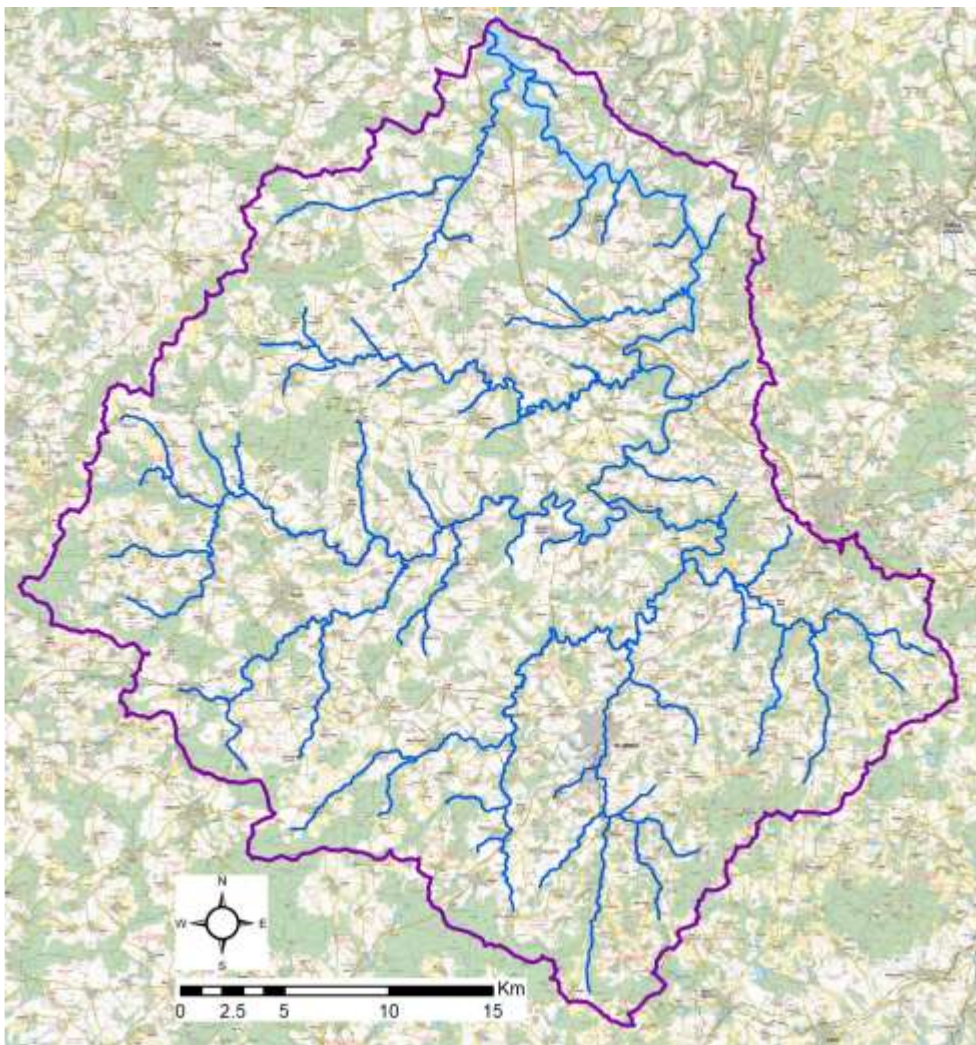


Švihov reservoir and surrounding landscape

PHISHES value: the test site links a strategic basin with soil – groundwater – surface-water transport processes



What is the test site?



Catchment boundary and river network

1 190 km²

Želivka basin

~51%

arable land in Želivka basin

315 – 765 m a.s.l.

elevation range

~30%

forests in Želivka basin

116 km²

Martinický potok catchment

~16%

green areas

Key characteristics:

- crystalline bedrock, **shallow aquifers** and Cambisol-dominated soils shape runoff and transport pathways
- **tile drainage** covering a good portion of the agricultural land
- the **basin is data-rich, but not uniformly**



What is the test site?

Data availability across the Želivka basin - cascade

Different spatial scales provide different data detail — a key reason for **cascade-based modelling**

Černí

Field laboratory — VERY HIGH DETAIL

- VUMOP monitoring since 2014
- Detailed farmer records
- Hydrology, WQ, drainage, groundwater, management

Small subcatchments

Chyšná / Suchý potok — HIGH DETAIL

- Good local monitoring
- Some field-scale management data
- Less complete than at Černí

Martinický potok basin

Catchment scale — MEDIUM DETAIL

- Good discharge and some WQ monitoring
- Event sampling at selected profiles
- Agricultural data only for parts of the catchment

Whole Želivka basin

Basin context — REGIONAL OVERVIEW

- Routine basin monitoring
- Statutory agricultural reporting
- Broad coverage, lower detail

Field scale

smaller area, higher data detail

Increasing spatial scale → decreasing data detail

Basin scale

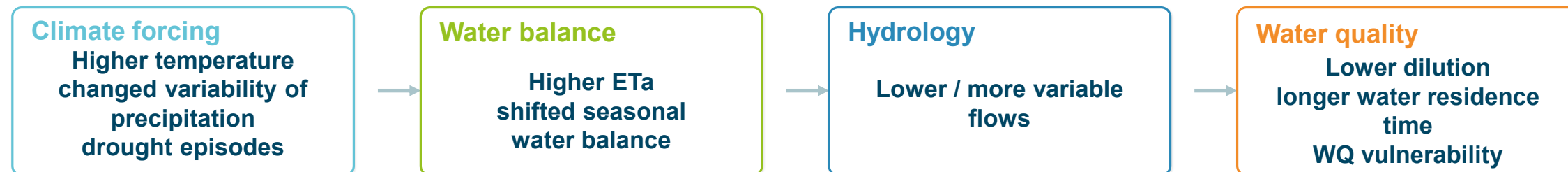
larger area, lower detail

PHISHES approach: data gradient is one of the reasons for cascade-based modelling and transfer of calibrated processes

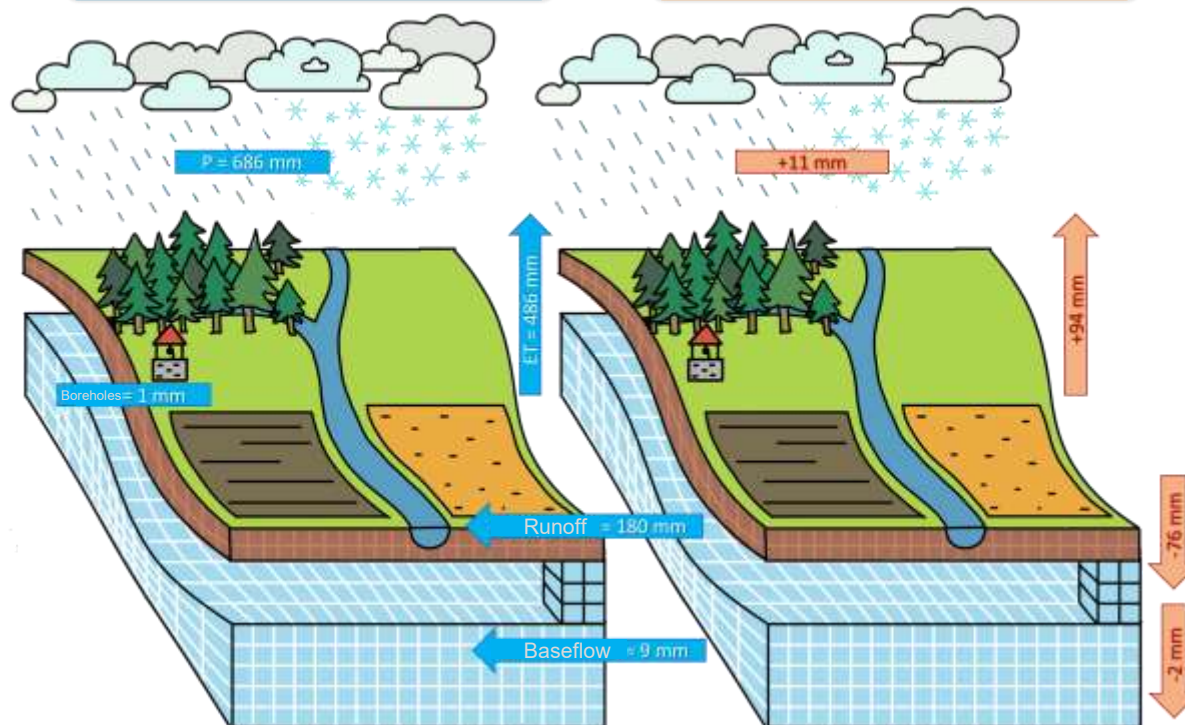


Why climate change matters?

The water quality problem is coupled to water quantity



- less water in tributaries means **less dilution** of nutrients, pesticides and metabolites
- short rainfall–runoff events can still drive concentration peaks and substance pulses
- management **scenarios must** therefore **combine** land use, soil condition, agricultural practises, drainage and tree species composition changes



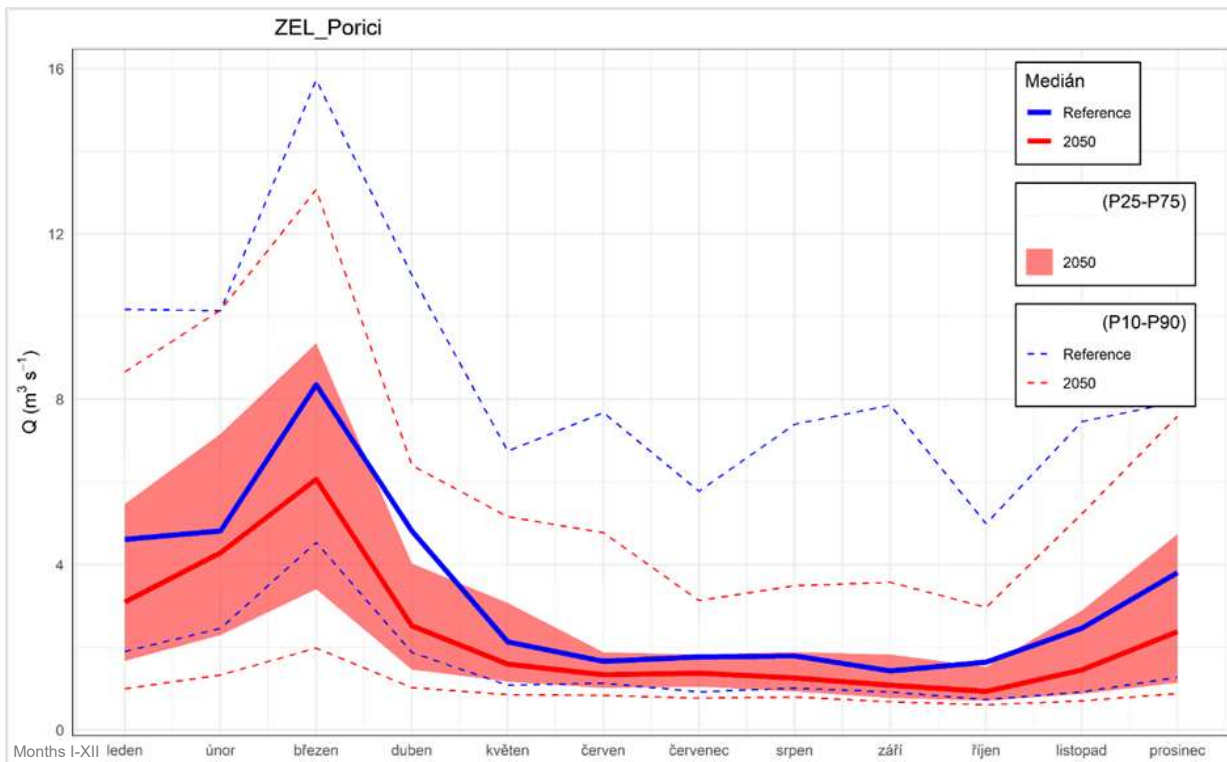
*Illustrative water-balance response: more ET, reduced runoff components
Water balance for the 1981–2010 reference period (left) and projected change around 2050 under SSP2-4.5 using the EC-EARTH GCM (right).*



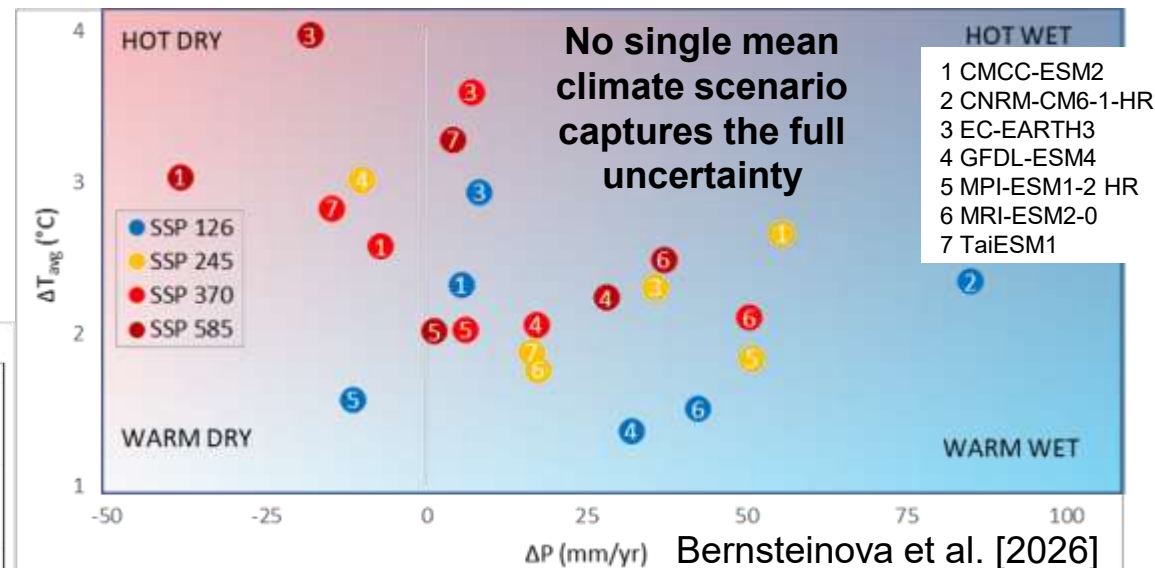
Why climate change matters?

Streamflow prognosis for Zelivka basin:

- Decrease of Q_a by 12 – 38% (2030)
26 – 49% (2050)
25 – 65% (2085)



There are no clear patterns in development of model in SSPs → importance of complex assessment



PHISHES goes beyond future runoff: it addresses coupled water and contaminant transport through the soil – water system under changing climate conditions.



How we monitor?

Routine monitoring alone is not sufficient for process understanding and model calibration/validation — targeted event-based and continuous monitoring is needed to capture short-term concentration dynamics.

- 1. **Routine operational monitoring:** ~monthly, weather independent; broad laboratory analysis but often misses rainfall–runoff events
- 2. **Automatic samplers:** triggered by water level changes - capture event samples with broad laboratory analysis, but at discrete times. Pre-event conditions and the true concentration peak may still be missed
- 3. **Continuous probes:** ~minute-scale data before, during and after events; best for process dynamics, but limited to fewer parameters and field-intensive



Onšov



Mohelnice



Suchý potok



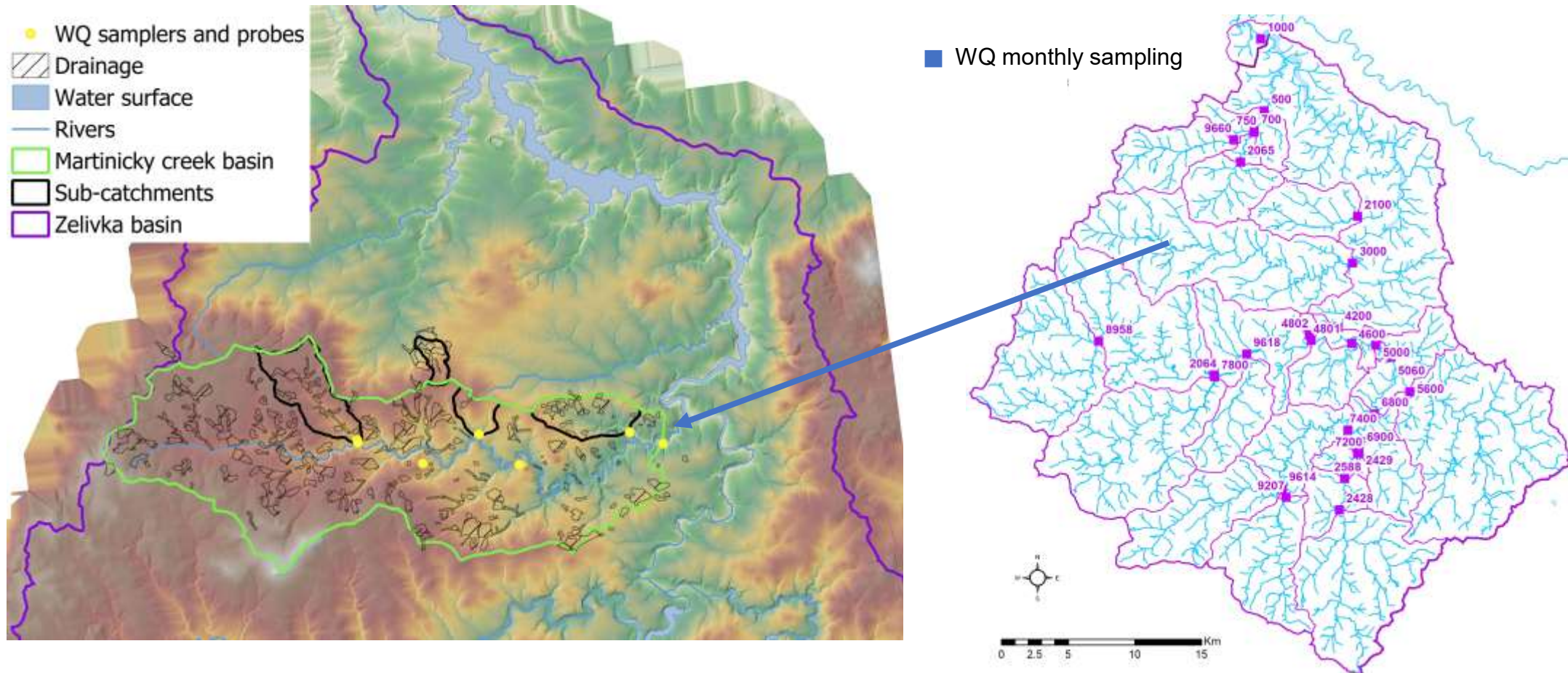
Černí

Newly installed monitoring profiles and field sampling locations



How we monitor?

The monitoring design captures both background conditions and short-lived runoff-driven peaks



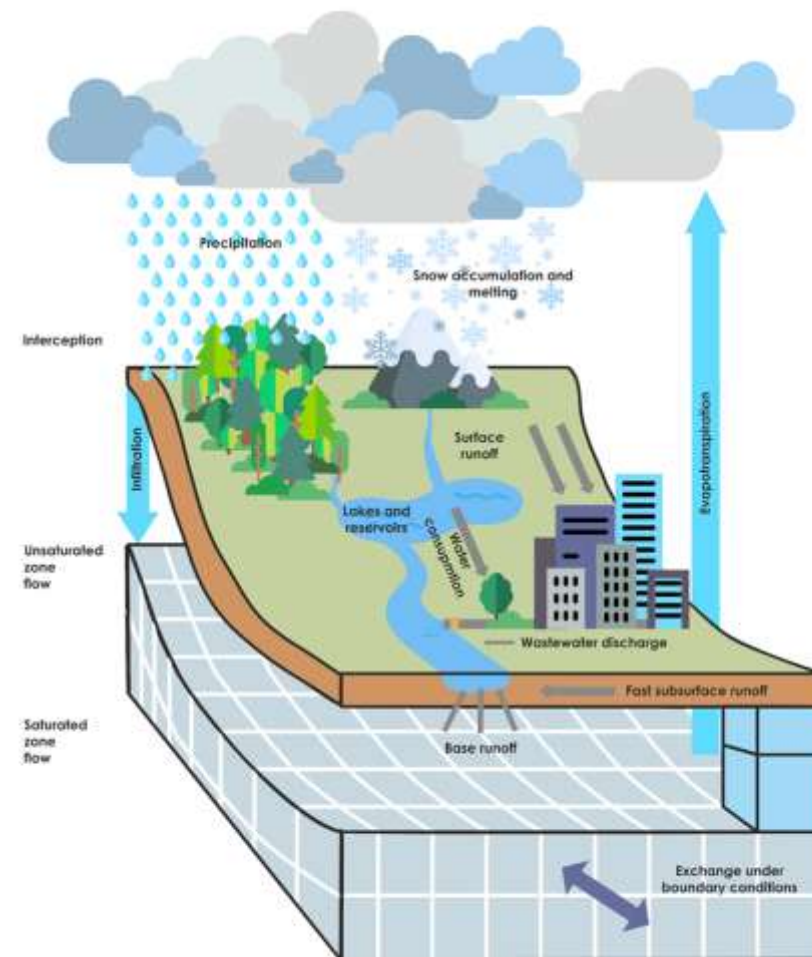
Leader CzechGlobe with partners: soil research institute VÚMOP and water basin authority Povodí Vltavy s.p.



How we model?

A physically based model train links soil health, hydrological pathways and WQ response

- MIKE SHE WM: complex physically based, distributed hydrological model - runoff processes and fully distributed surface and subsurface water movement
- MIKE SHE WQ / Advection–Dispersion approach: event-based transport and first-order decay for selected chemicals
- MIKE ECO Lab: add-on for chemicals transformation and schematization of reactions
- DAISY: column-type soil-water process schematisation, nitrogen cycle simulation



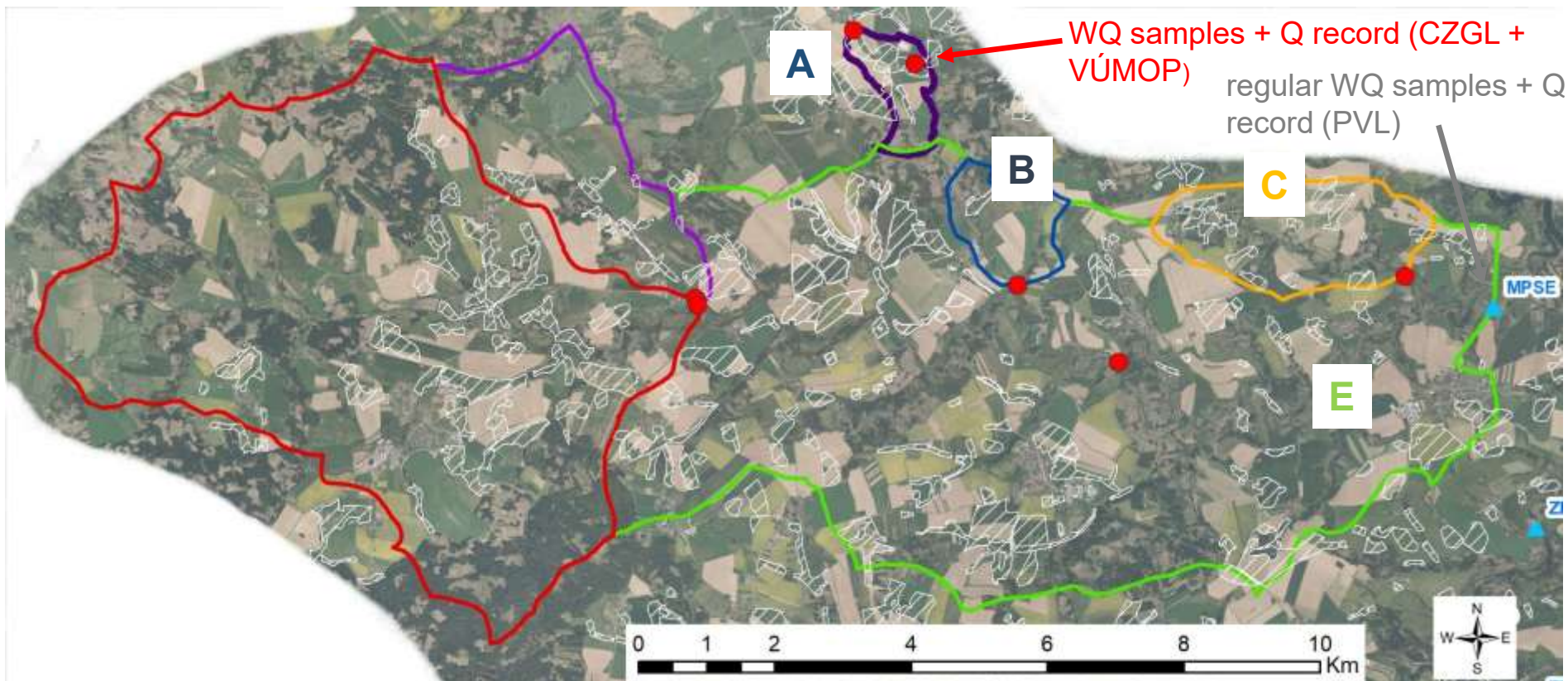
MIKE SHE representation of key water-movement pathways

Purpose: turn monitoring data into a scenario-ready tool for climate, land-use and agricultural-management variants.



How we model?

Detailed process knowledge is tested for transfer to larger, decision - relevant scales



Nested catchments in Martinický potok (E): Černíčí (A), Chyšná (B), Suchý potok (C)

A / Černíčí, research microcatchment (1.4 km²): detailed calibration and process understanding



B and C subcatchments (2 and 5 km²): independent calibration and transferability tests



E / Martinický potok catchment (113 km²): extension and upscaling of WQ approach



Želivka river basin (1190 km²): long-term scenarios and management relevance

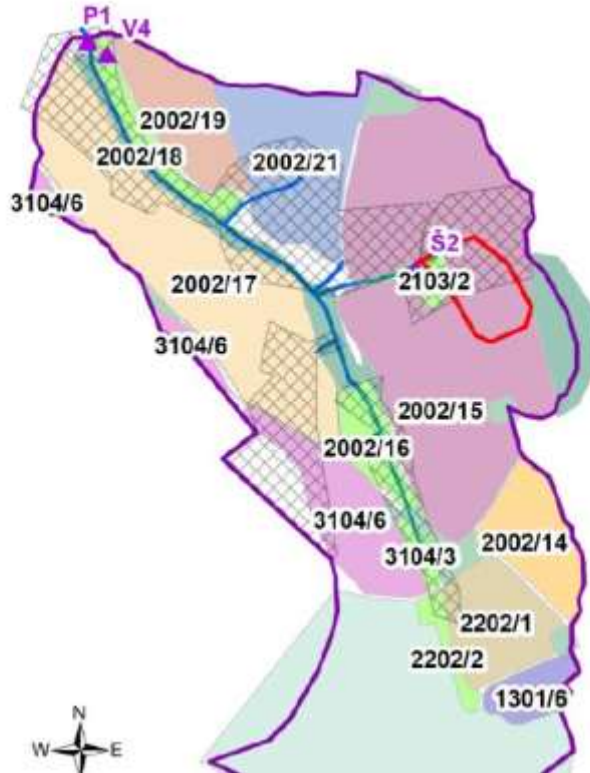
PHISHES scientific question: can detailed soil–water process understanding be scaled up?



What we know so far?

First operational model trains at microcatchment A

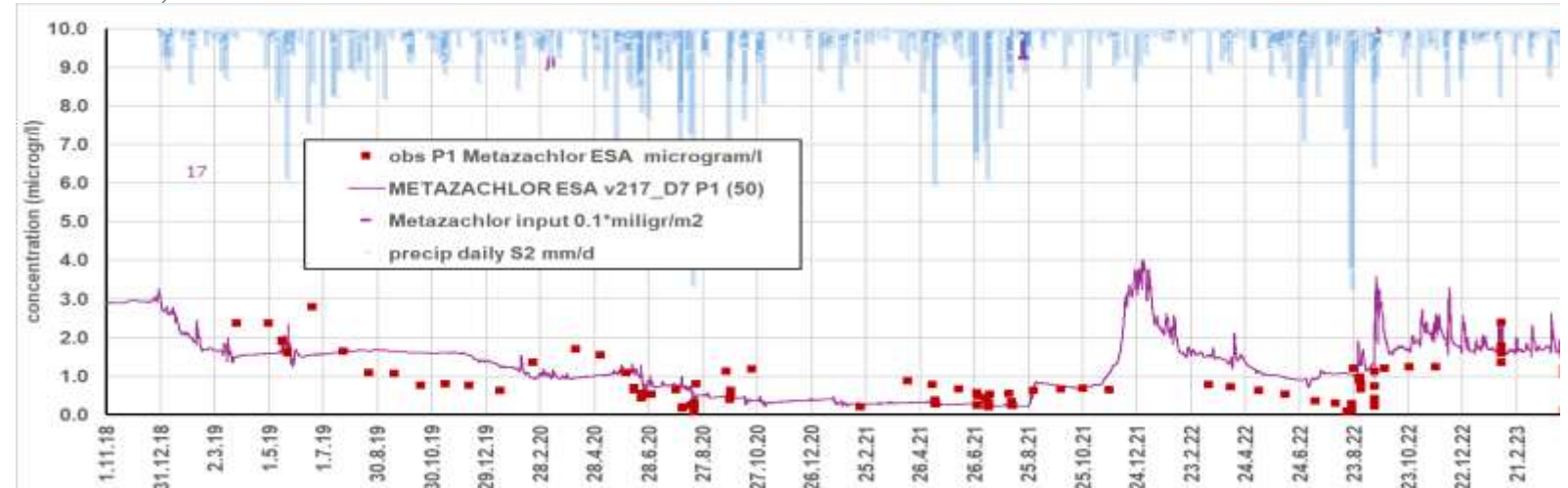
Current results are promising but remain preliminary and validation-dependent



Research microcatchment A:
monitoring points, agricultural units
and tile drainage areas

- WM model calibrated using 10 min. records for 1.11.2013 – 30.9.2025 period
- event-based AD transport used for plant protection products (parent compound)
- AD transport with MIKE ECO Lab used for parent compounds and their metabolites

Metazachlor ESA concentration long-term simulation (line) compared with observations (dots).
P1 outlet, microcatchment A



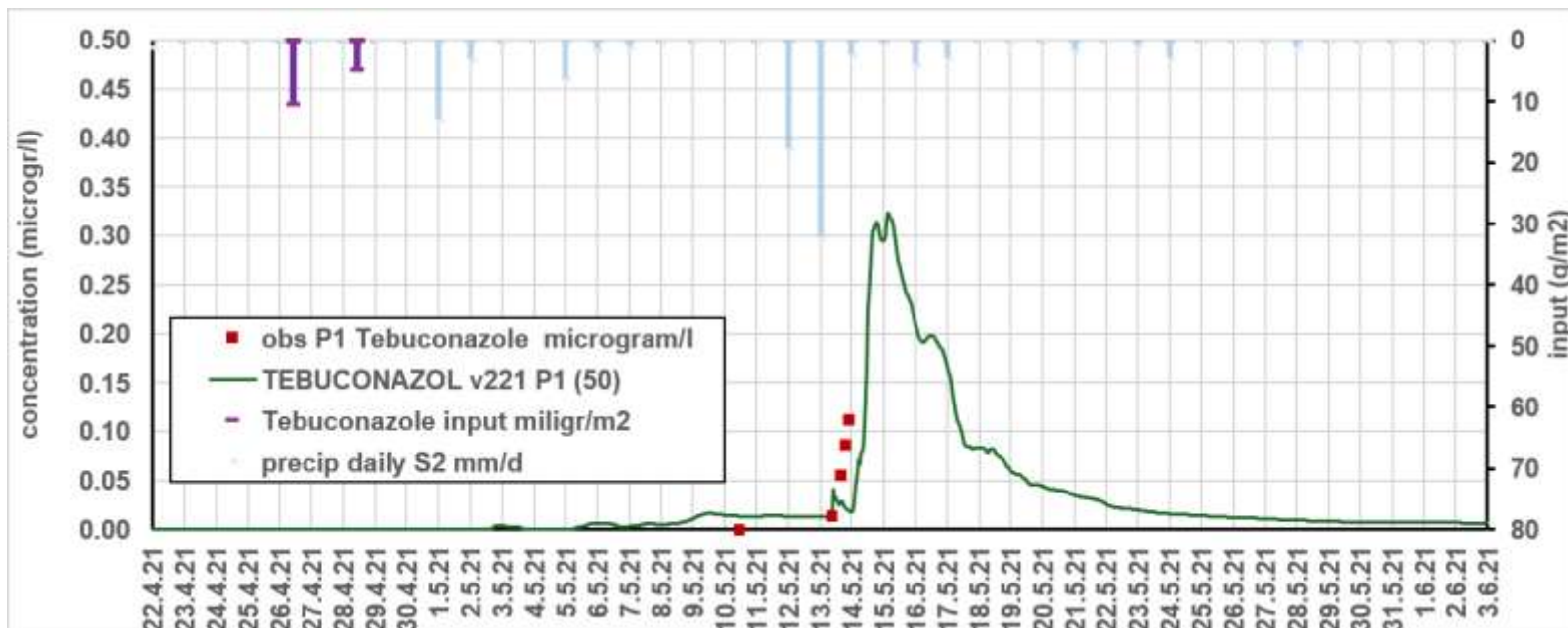


What we know so far?

First WQ signals: events, drainage and macropores

PRELIMINARY FINDINGS

- fast surface runoff is rare in microcatchment A and has **minor impact** on the investigated **concentrations**
- artificial **drainage areas** are **key** for runoff formation and transport of event-based and long-term pollution
- a **two-domain unsaturated zone approach** - matrix + macropores - is necessary in most cases
- robust **WQ simulation** requires a **correct** (= well calibrated) **rainfall-runoff model** and overall water balance first



Comparison of observed (red dots) and simulated (green line) concentrations of Tebuconazole in selected event at outlet P1. Research microcatchment A

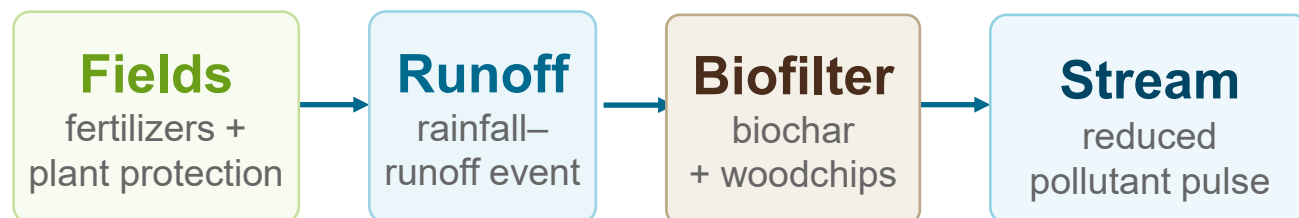
Monitoring + modelling must be designed around events, not only long-term averages



What we know so far?

Chysna biofilter pilot

Concept: Testing a simple nature-based barrier for agricultural runoff before it enters the stream



Overall view over Chysna microcatchment

First test signals

Strong retention was observed for tebuconazole under shock exposure, while glyphosate showed faster breakthrough. For the ordinary pesticide mixture, paired samples indicate about 30% reduction, on average.

Biofilter (top) set up





What we know so far?

Next steps and takeaways

NEXT MODELLING PHASE

- **continue** meteorological, discharge and WQ **monitoring** in Martinický potok
- **test event-transport models** for plant protection products against additional suitable events
- **Nesting approach** - independently calibrate B and C water-movement models, then transfer WQ approach from $A \rightarrow B/C \rightarrow E$
- prepare and compare land-use, agricultural-management and climate-related **scenarios** against baseline

TAKEAWAYS

Strategic basin

Želivka/Švihov is sensitive because water quality depends on the whole soil–water system.

Climate matters

Lower flows reduce dilution capacity and amplify existing WQ pressures.

Data + monitoring

The cascade uses uneven but uniquely valuable data across scales.

PHISHES contribution

Nested, physically based models connect detailed process understanding with basin-scale scenario assessment.

PHISHES connects processes, data and models across scales — from field experiments to basin-scale scenarios.



Thank you for your kind attention

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