OPTAIN

OPtimal strategies to retAIN and re-use water and nutrients in small agricultural catchments across different soil-climatic regions in Europe

Application of a new, scripted SWAT+ modelling workflow in 14 small agricultural catchments in Europe: from input data to scenario output

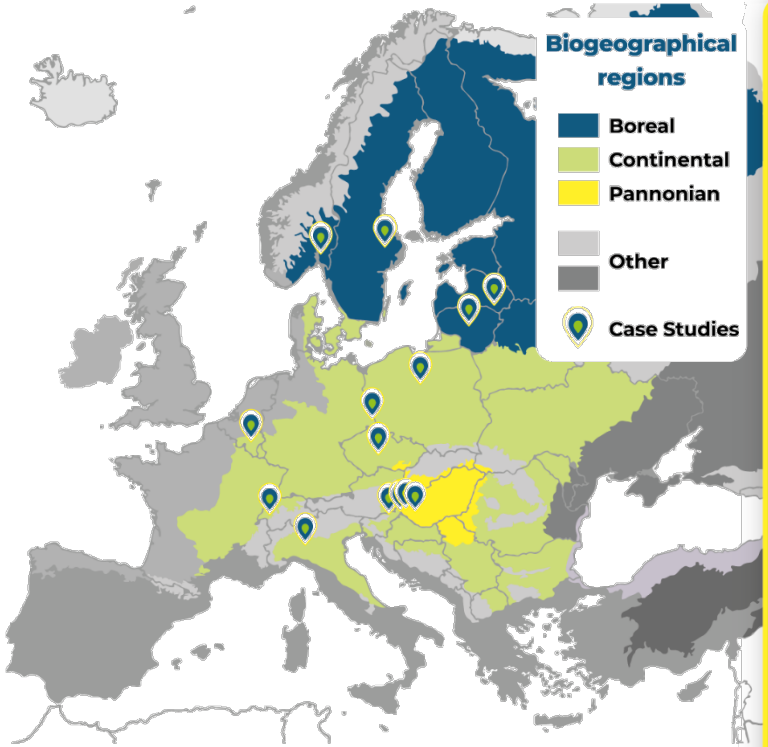
Mikołaj Piniewski, Michael Strauch, Svajunas Plunge, Christoph Schürz, Natalja Čerkasova, Enrico Chiaradia, Felix Witing

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No. 862756.

OPTAIN

Optimal Strategies to Retain Water and Nutrients

PROJECT INFO



21 partners from 15 countries across Europe

14 partners will contribute with their own case study

7 million Euro budget

5 years duration 2020-2025

@H2020OPTAIN

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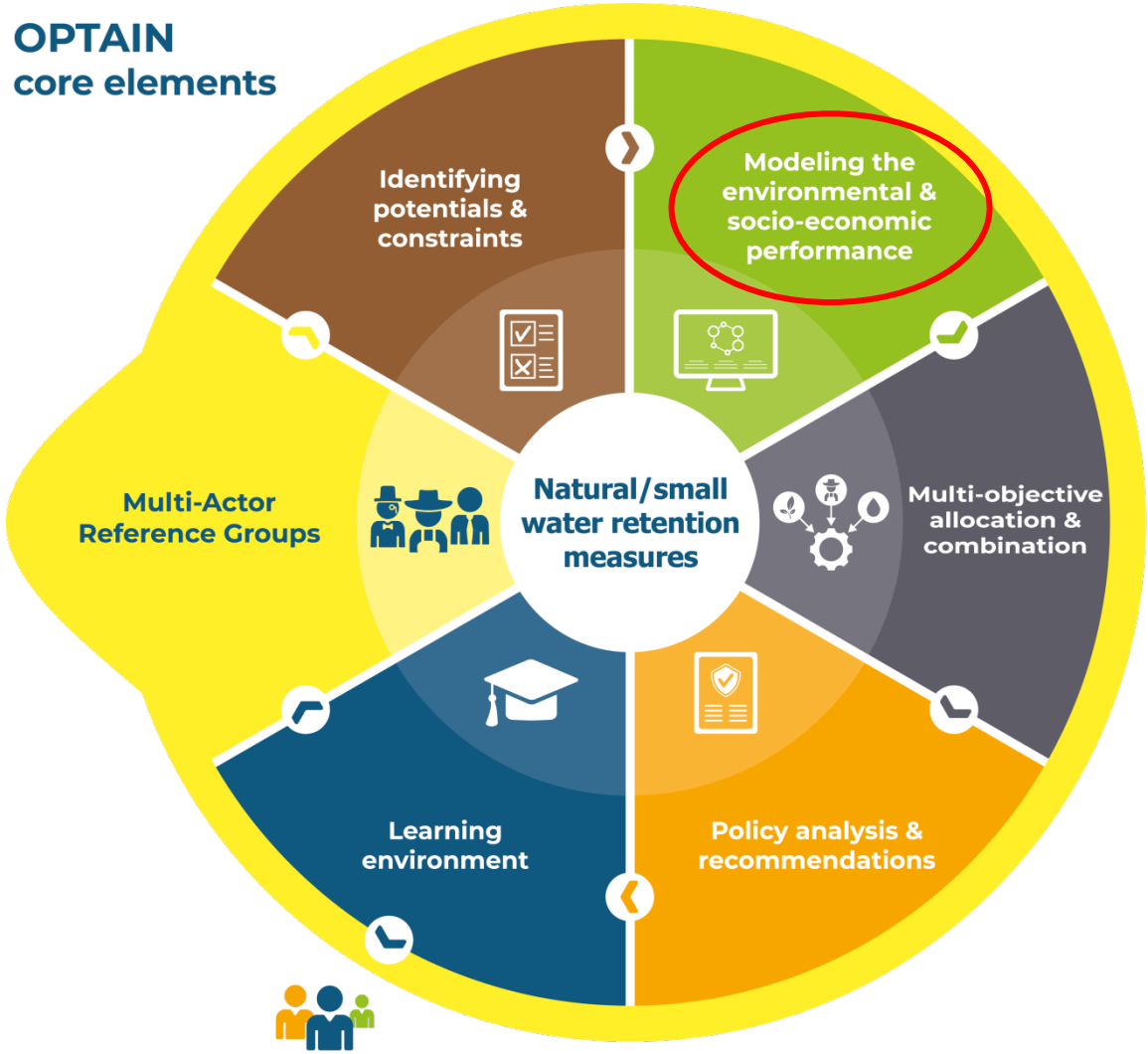
Coordinator
Prof. Dr. Martin Volk
Helmholtz Centre for Environmental Research – UFZ

WWW.OPTAIN.EU

OPTAIN core elements



H2020
GA 862756

Outline

- A bird's eye view of the OPTAIN harmonisation and scripted workflows
- A few snapshots of the results of applying the developed modelling workflow in European catchments

Harmonisation – OPTAIN's holy grail

Context: 14 small (~50-200 km^2) agricultural catchments in 12 European countries, project focusing on NSWRM

Why?

Transparency & reproducibility

Facilitating cross-catchment comparisons

Serving as a benchmark for future SWAT+ applications

In OPTAIN harmonisation refers to:

(1) Input data: Using either locally best available data sources or state-of-the-art European data

(2) Methods/approaches: guidelines provided in the „modeling protocol"

(3) Tools: SWAT R ecosystem

Modelling protocol for the assessment of NSWRMs in small agricultural catchments

Protocol: state-of-the-art methodological guidance on best modelling practice

New tools supporting the modelling process

Introducing the COntiguous object COnnectivity Approach (COCOA)

Covering: baseline model setup preparation, model parametrisation (incl. agricultural management), model evaluation, scenario setup (climate & NSWRM)

Designed as a guide to 14 OPTAIN case studies, but beneficial to the wider modelling community

Available at OPTAIN Zenodo repository **bit.ly/optain_zenodo** (approaching 1000 downloads ☺)

SWAT+

SOIL & WATER ASSESSMENT TOOL

OPTAIN

SWAT+ modeling protocol for the assessment of water and nutrient retention measures in small agricultural catchments

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant agreement No. 862756.

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2022-12-20

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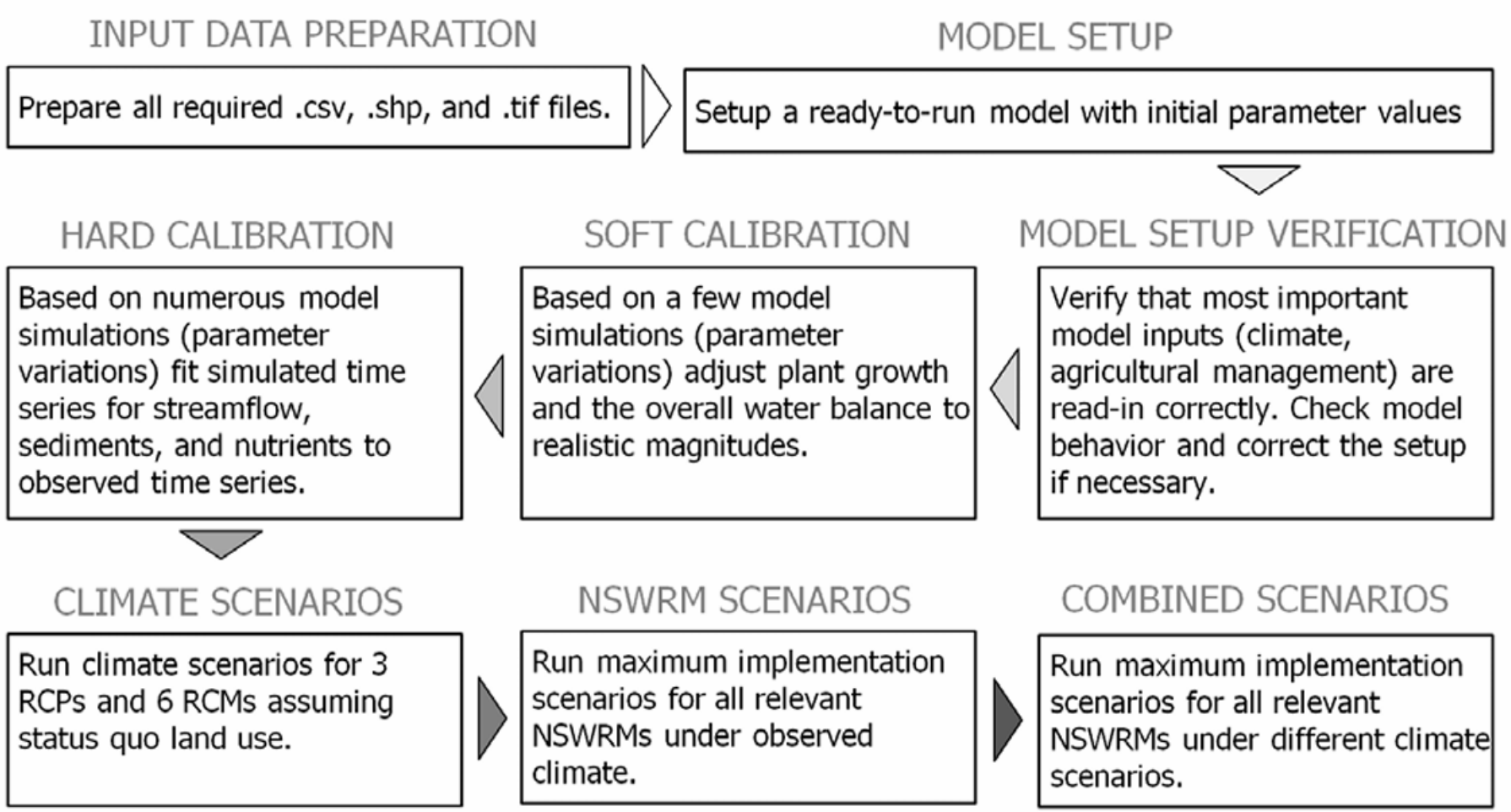
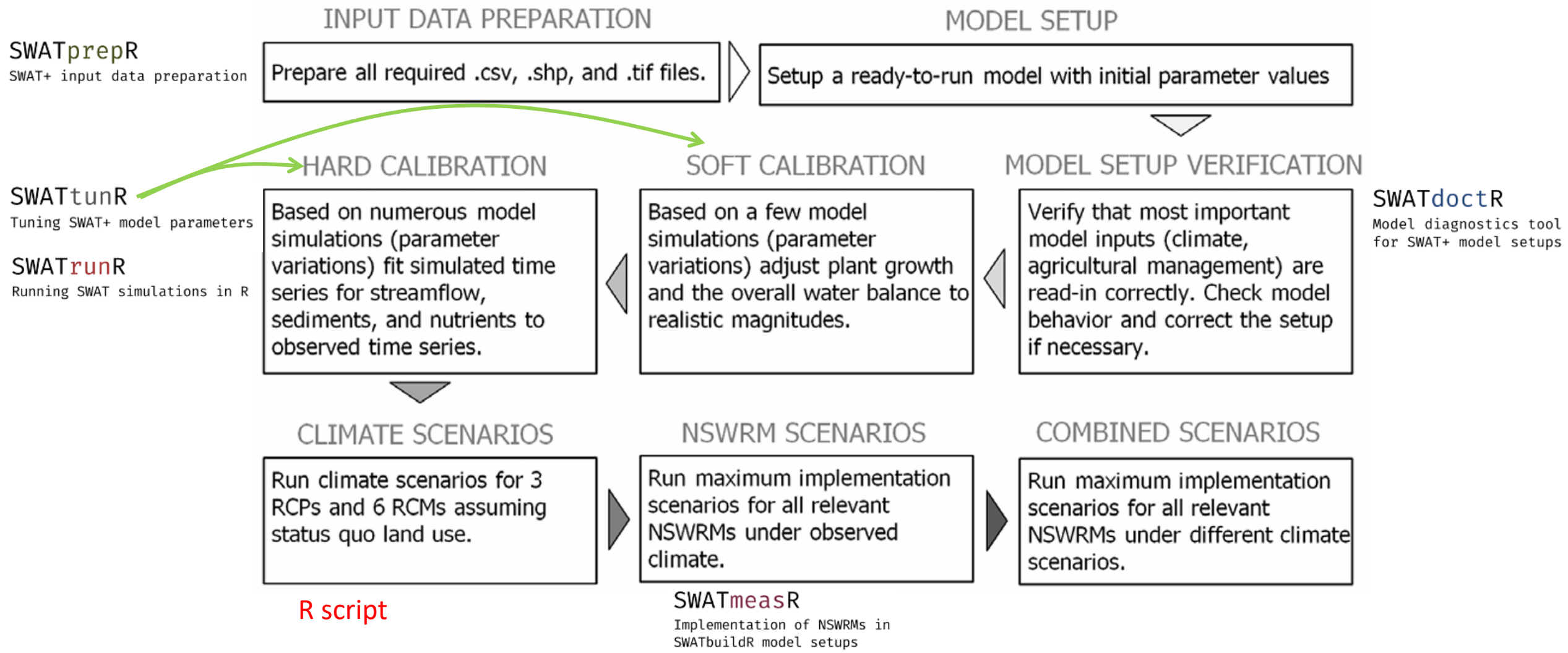
Workflow - overview



Workflow + tools - overview

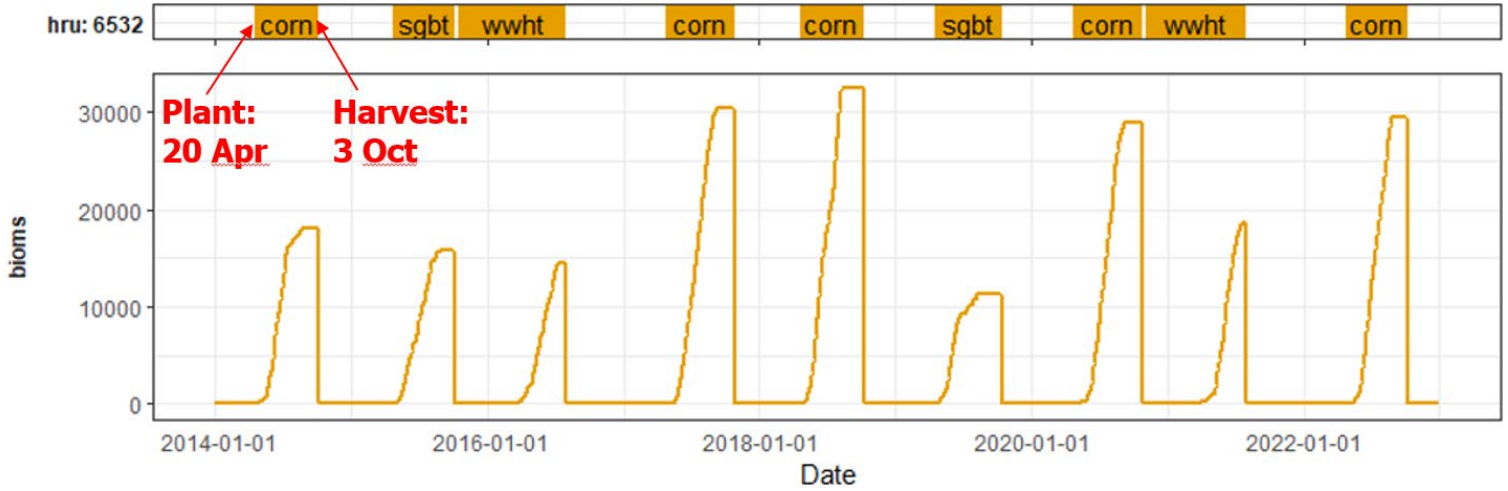
SWATbuildR
An object connectivity based SWAT+ model builder

SWATfarmR
Simple rule based management operation scheduling



Key requirements for SWAT+ model setups in OPTAIN

1. Individual fields as HRUs with their crop rotations and associated management



Mészáros, J., & Szabó, B. (2022). Script to derive and apply crop classification based on Sentinel 1 satellite radar images in Google Earth Engine platform (cropmap). Zenodo. https://doi.org/10.5281/zenodo.6700122

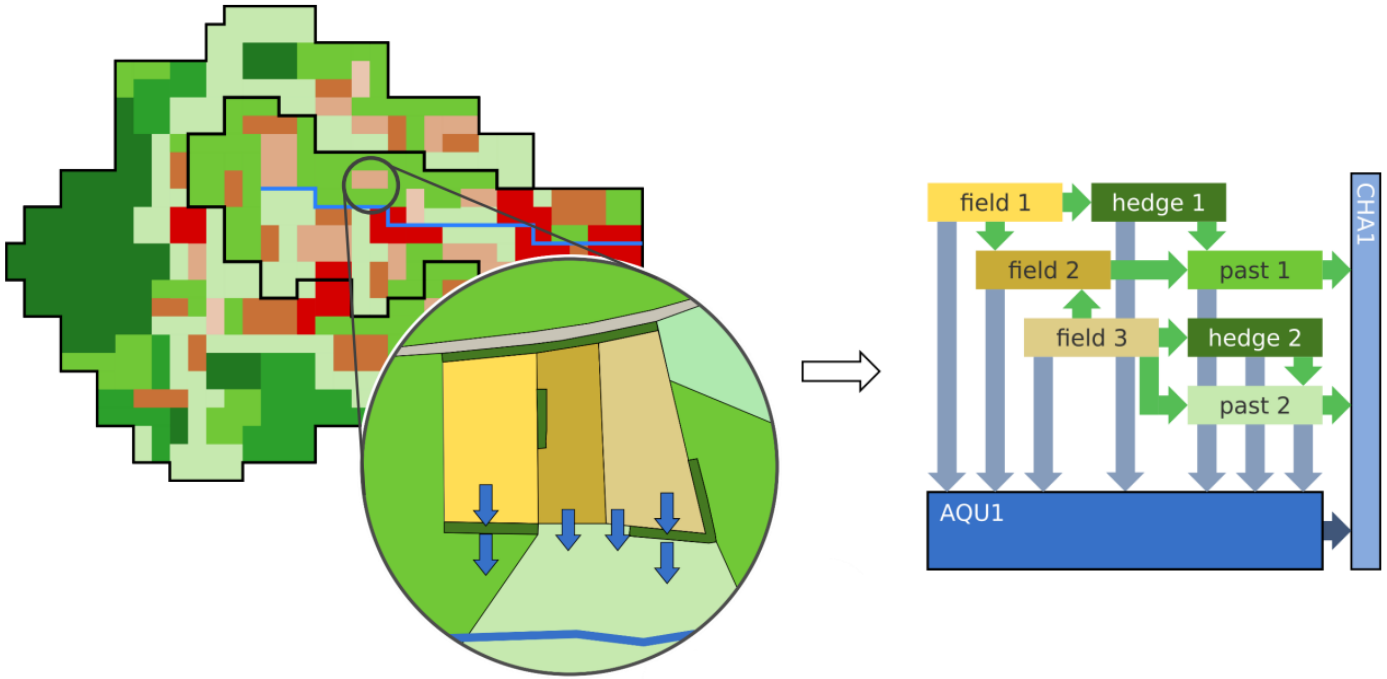
SWATfarmR

Simple rule based management operation scheduling

OPTAIN

Key requirements for SWAT+ model setups in OPTAIN

2. Allow contiguous routing between all land and water objects

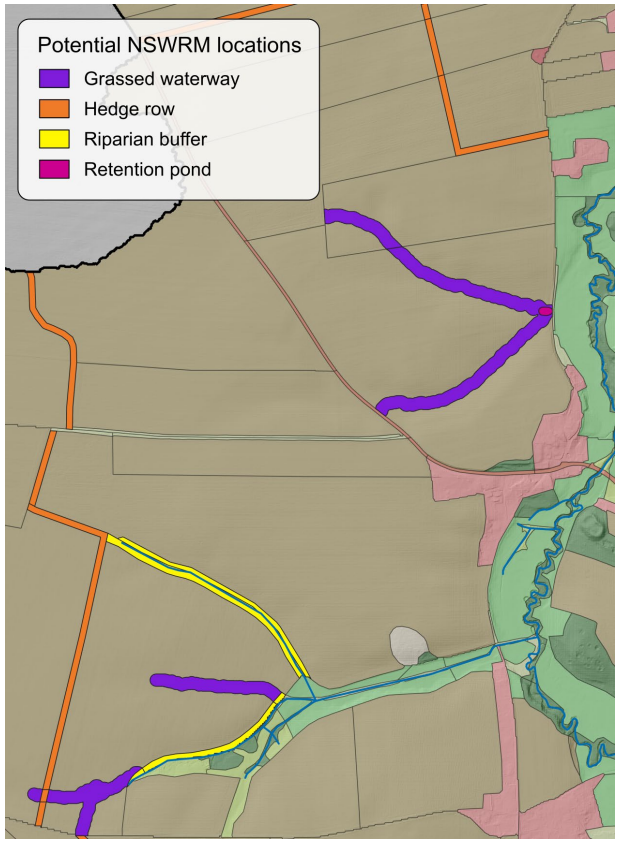


SWATbuildR

An object connectivity based SWAT+ model builder

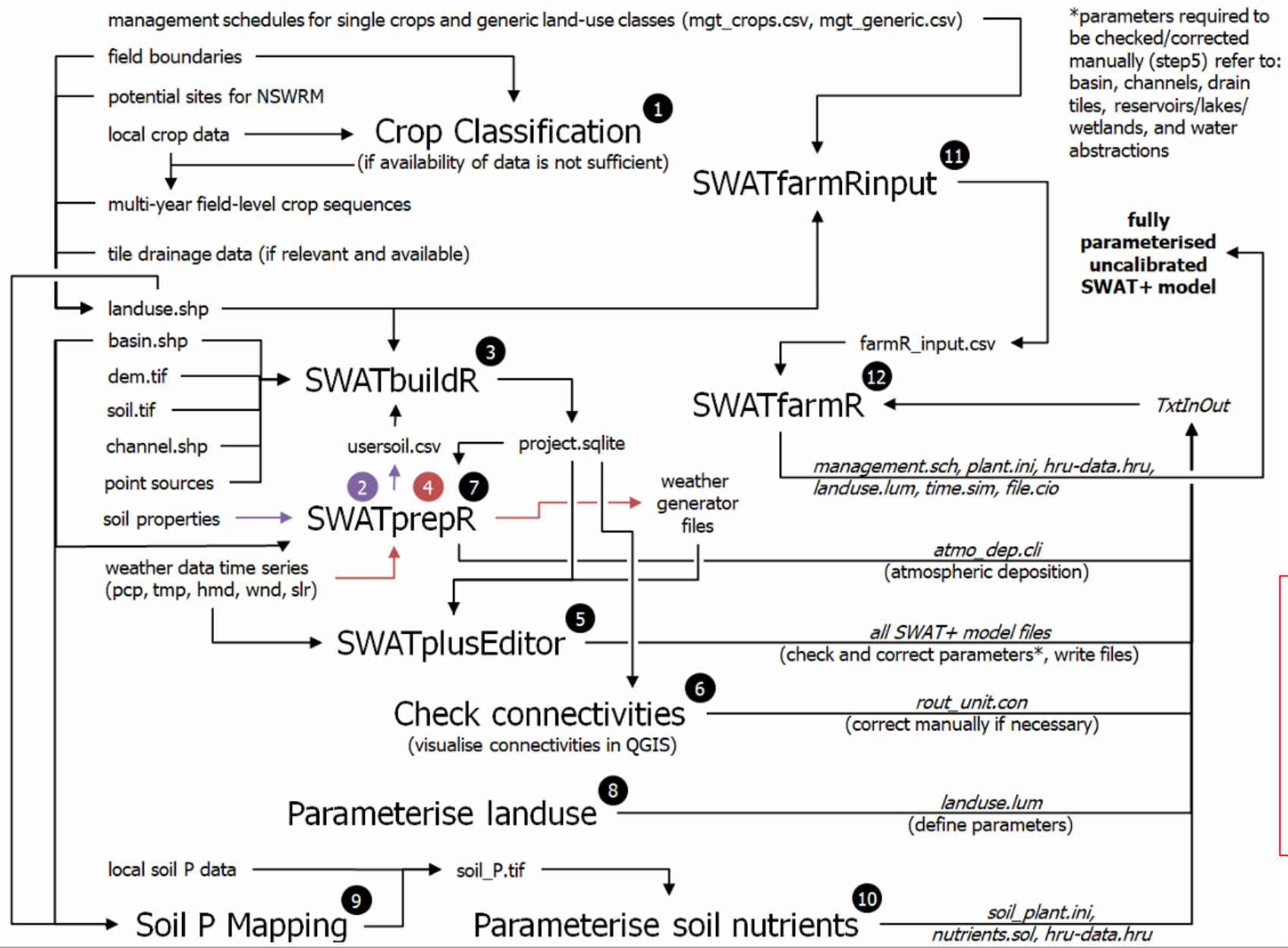
Key requirements for SWAT+ model setups in OPTAIN

3. Allow for spatially-explicit representation of selected structural NSWRMs at HRU level



SWATmeasR
Implementation of NSWRMs in SWATbuildR model setups

Workflow for setting up a ready-to-run SWAT+ model



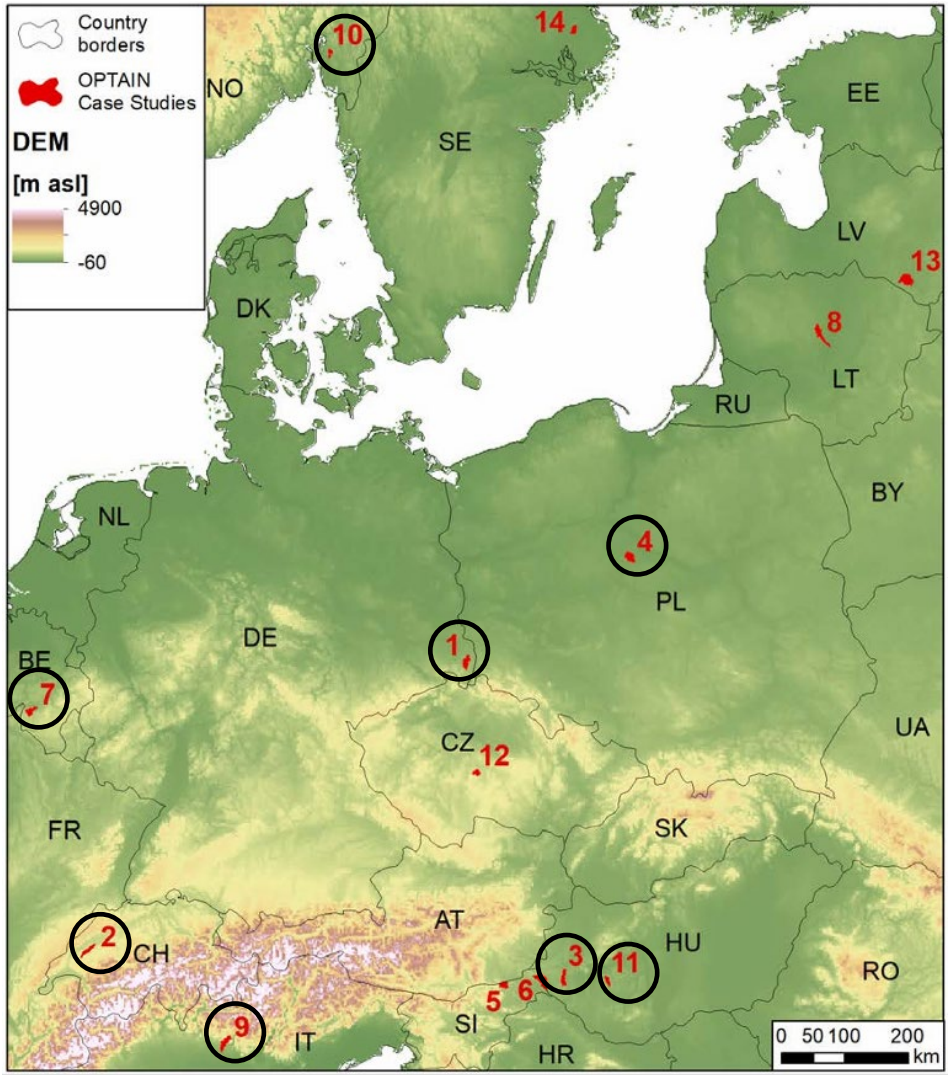
Plunge, S., Piniewski, M., Schürz, C., & Strauch, M. (2024). SWAT+ model setup preparation scripted workflow (in R language). Zenodo. https://doi.org/10.5281/zenodo.12564534

OPTAIN SWAT+ model setups

	Case Study / catchment		Model setup		Model evaluation				Scenarios	
			SWAT buildR	SWAT farmR	SWAT doctR	Soft calibration	Hard calibration	Validation	Climate change	NSWRM
✓	CS1 (DE)	Schwarzer Schöps								
✓	CS2 (CH)	Petite Glâne								
✓	CS3 (HU)	Felső-Válicka								
✓	CS4 (PL)	Upper Zgłowiączka								
	CS5 (SI)	Pesnica								
	CS6 (SI/HU)	Kebele / Kobiljski								
✓	CS7 (BE)	La Wimbe								
	CS8 (LT)	Dotnuvele								
✓	CS9 (IT)	Cherio								
✓	CS10 (NO)	Kråkstad								
✓	CS11 (HU)	Tetves								
	CS12 (CZ)	Cechticky								
	CS13 (LV)	Dviete								
	CS14 (SE)	Sävjaan								

Note: completed, in progress, not started

Status: March 2024

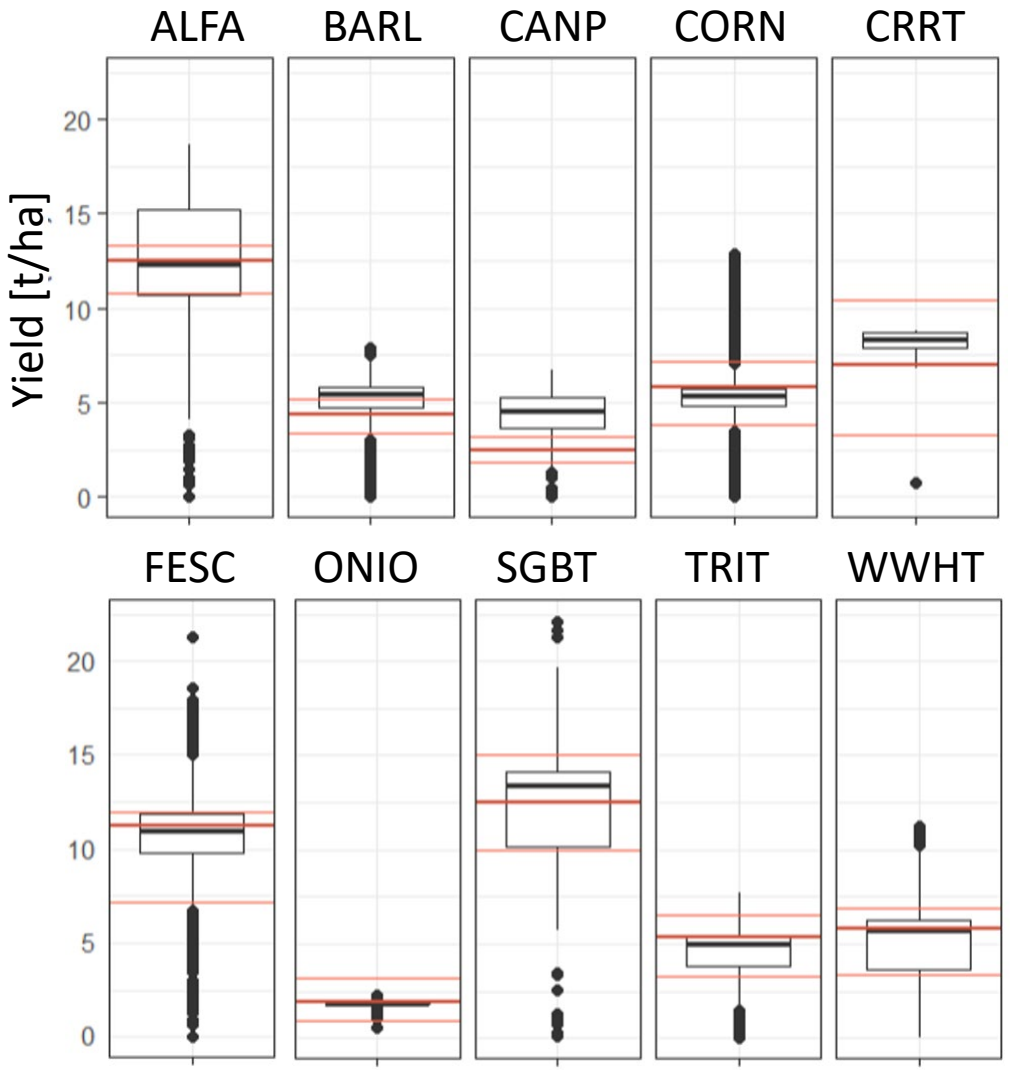


Results: crop yield soft calibration

Parameter changes for winter wheat across Case Studies

Case Study	Days to maturity ('d_mat')	Potential LAI ('lai_pot')	Harvest index ('harv_idx')	Biomass energy ratio ('bm_e')
Change method	Absolute change	Relative change		
CS1 (DE)	-50	-0.03	0.22	0.11
CS2 (CH)	-30	0	0.25	0
CS3 (HU)	-45	0	-0.15	0
CS4 (PL)	-70	0.2	0.2	0.1
CS7 (BE)	-30	0.5	0.05	0.21
CS9 (IT)	-105	0	0.4	1.5
CS10 (NO)	-40	0.63	0.29	0
CS11 (IT)	-50	0	-0.1	0
CS12 (CZ)	-60	0	0.3	0

Average simulated vs observed crop yields (CS4 – PL)

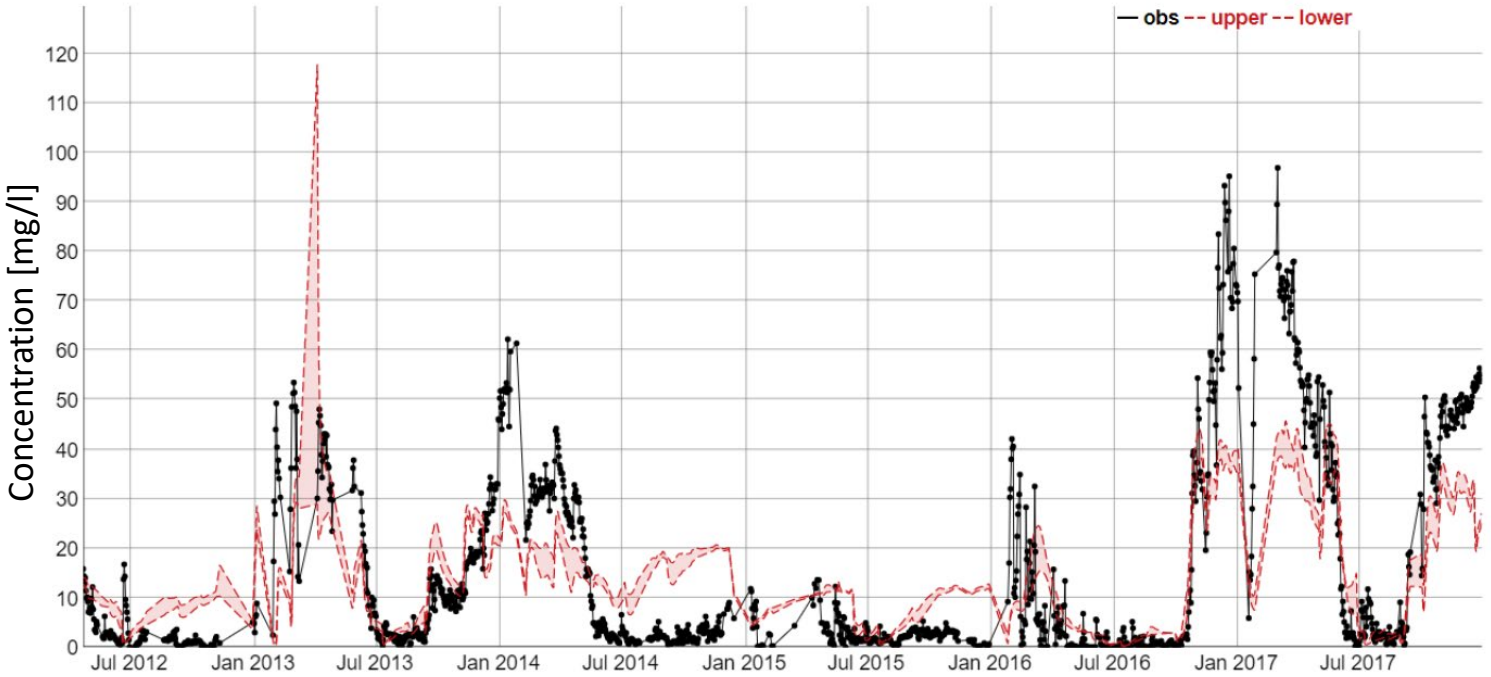


Results: hard calibration (discharge / nutrients)

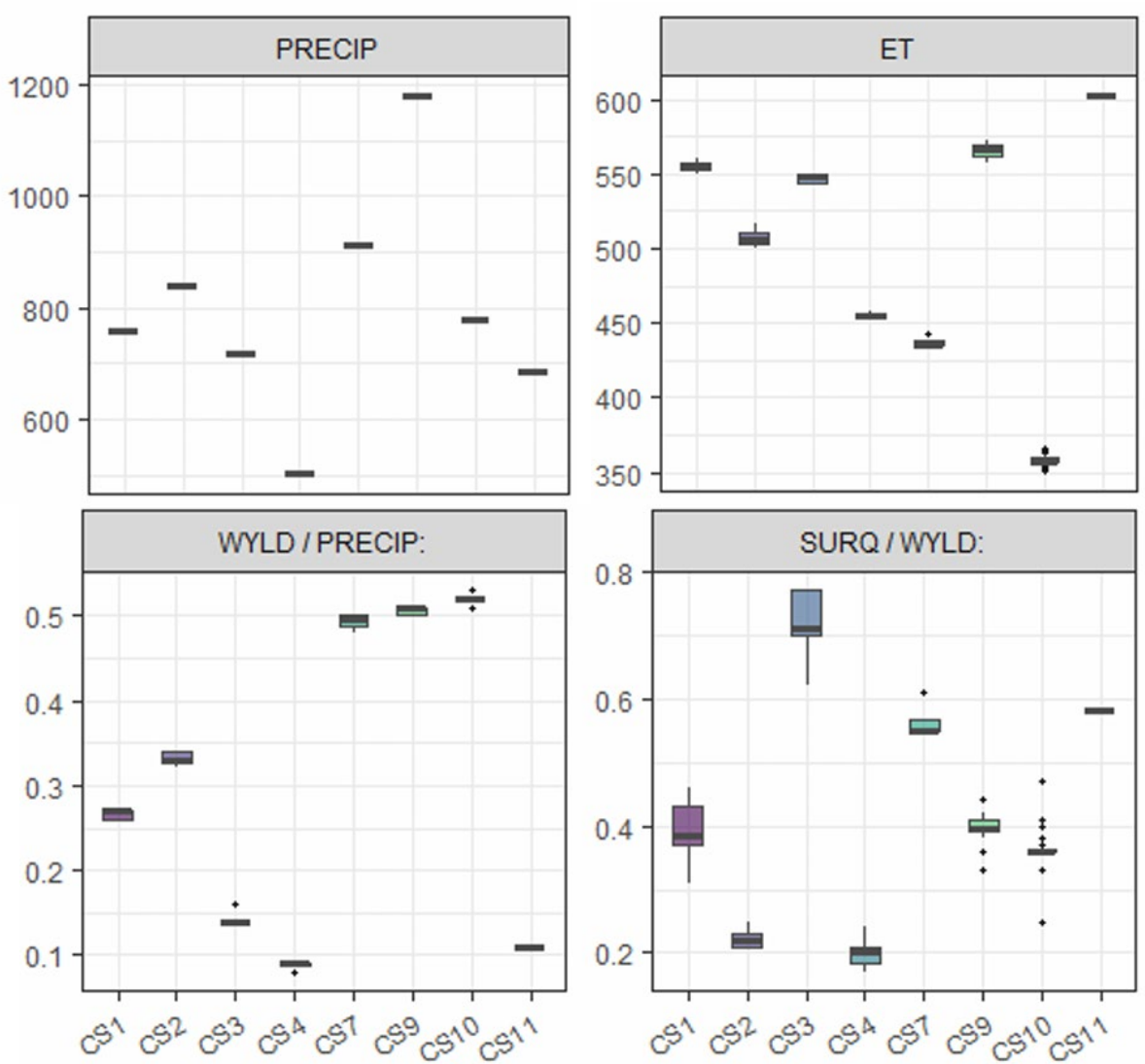
Model performance metrics across Case Studies

Case Study	Discharge			Water quality			
	KGE	NSE	PBIAS	Variable	KGE	NSE	PBIAS
CS1 (DE)	0.79	0.69	-0.4	TP load	0.79	0.67	-5.5
CS2 (CH)	0.83	0.80	-3.7				
CS3 (HU)	0.57	0.33	-7.0				
CS4 (PL)	0.81	0.63	-0.9	NO_3-N conc	0.51	0.59	-7.6
CS7 (BE)	0.81	0.75	-4.2	NO_3-N conc			-53.2
CS9 (IT)	0.76	0.56	-3.2				
CS10 (NO)	0.78	0.66	5.3	TN conc	0.78	0.68	5.2
CS11 (HU)	0.75	0.58	-1.3	NO_3-N conc	0.33	-0.33	-20.1

Calibration plot for N-NO_3 concentrations (CS4 – PL)



Simulated outputs for the baseline period



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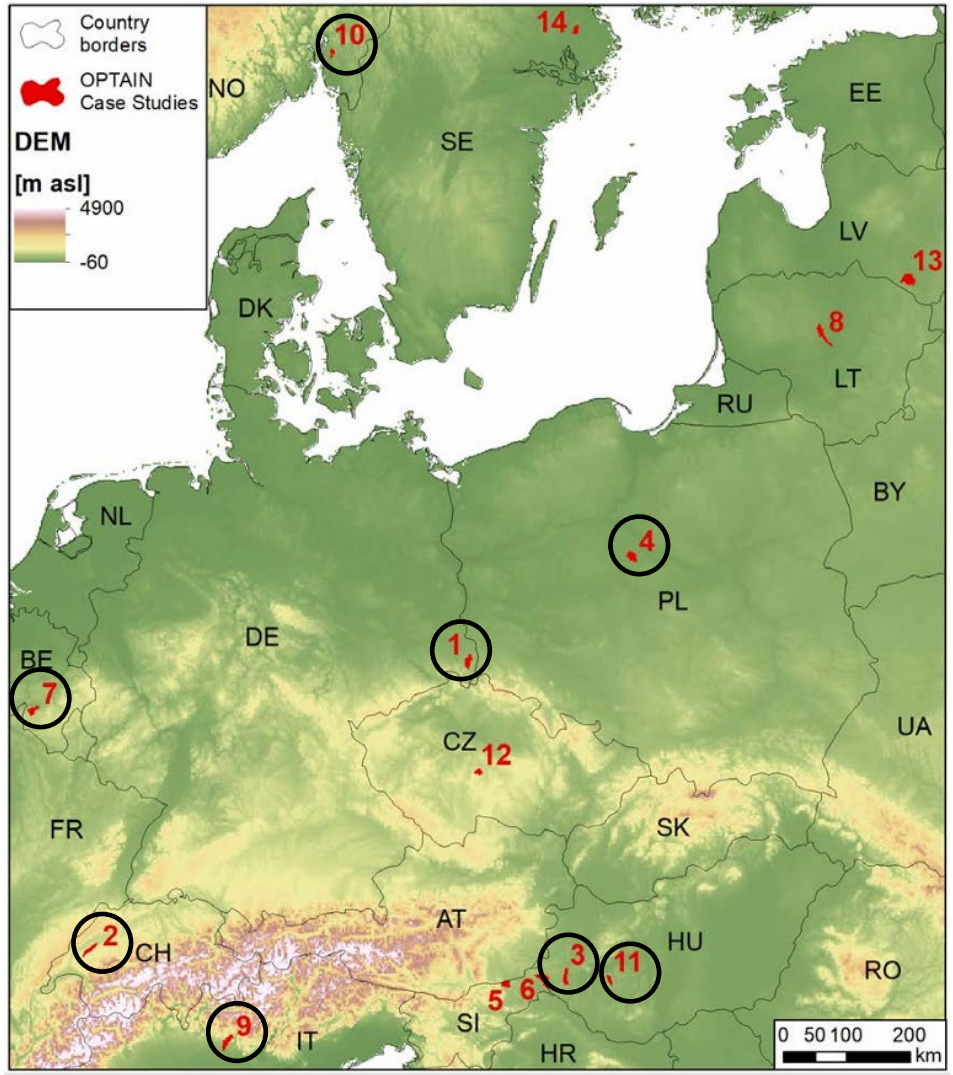

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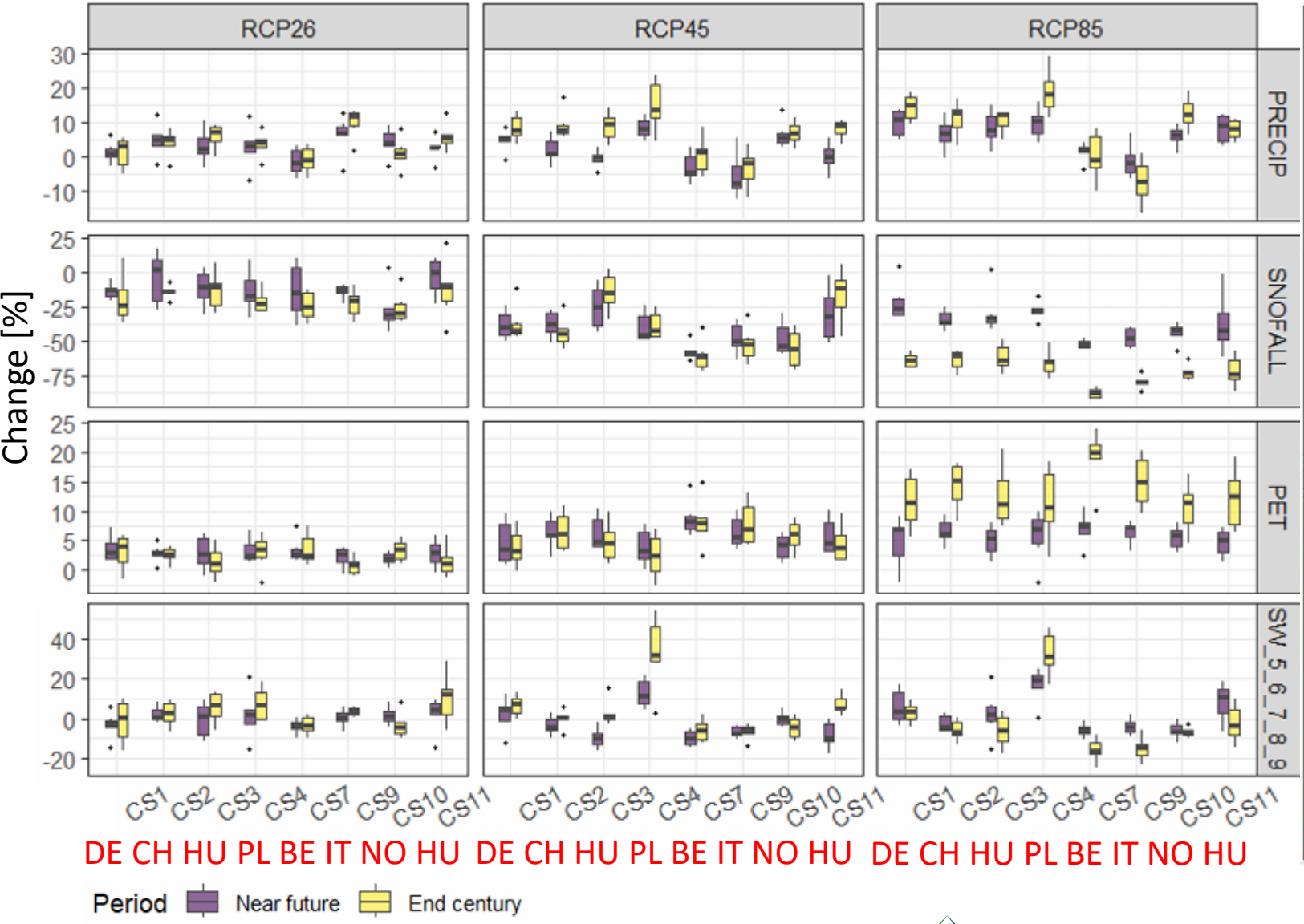
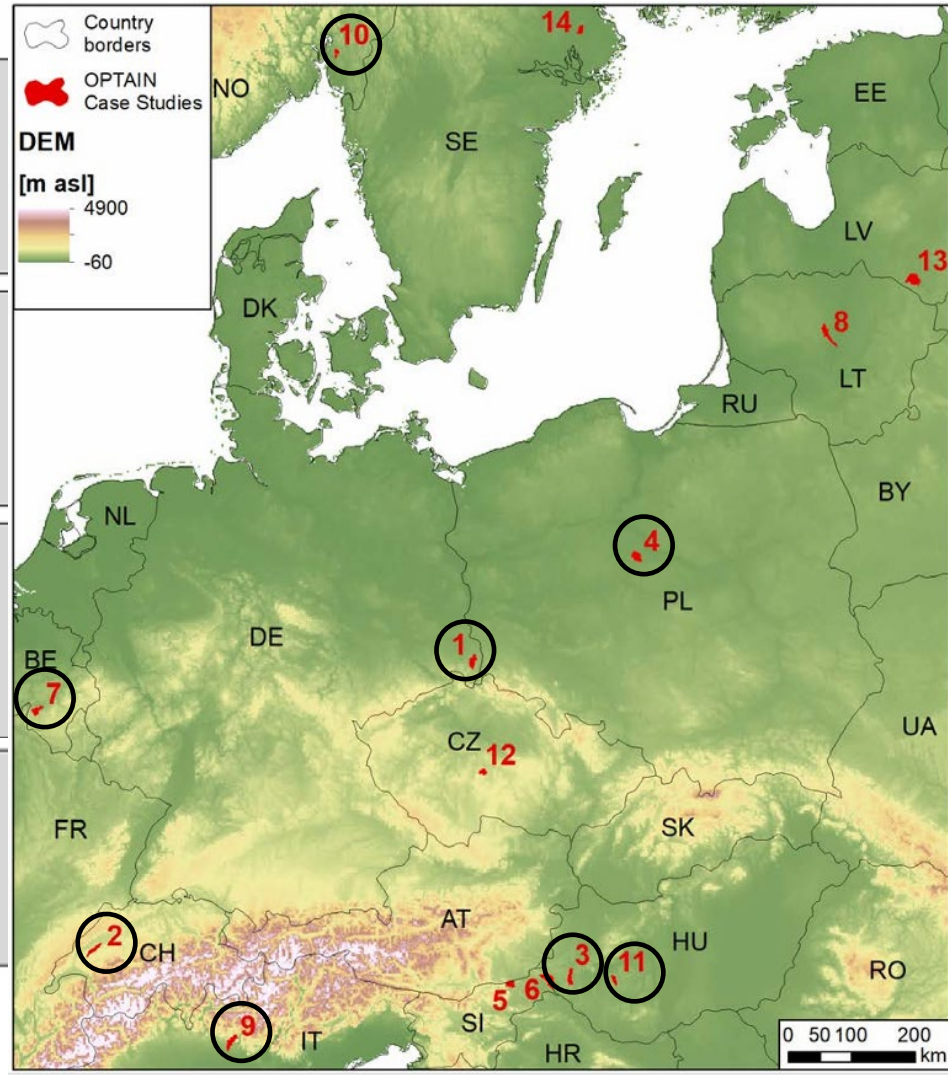
Climate change effects on water balance





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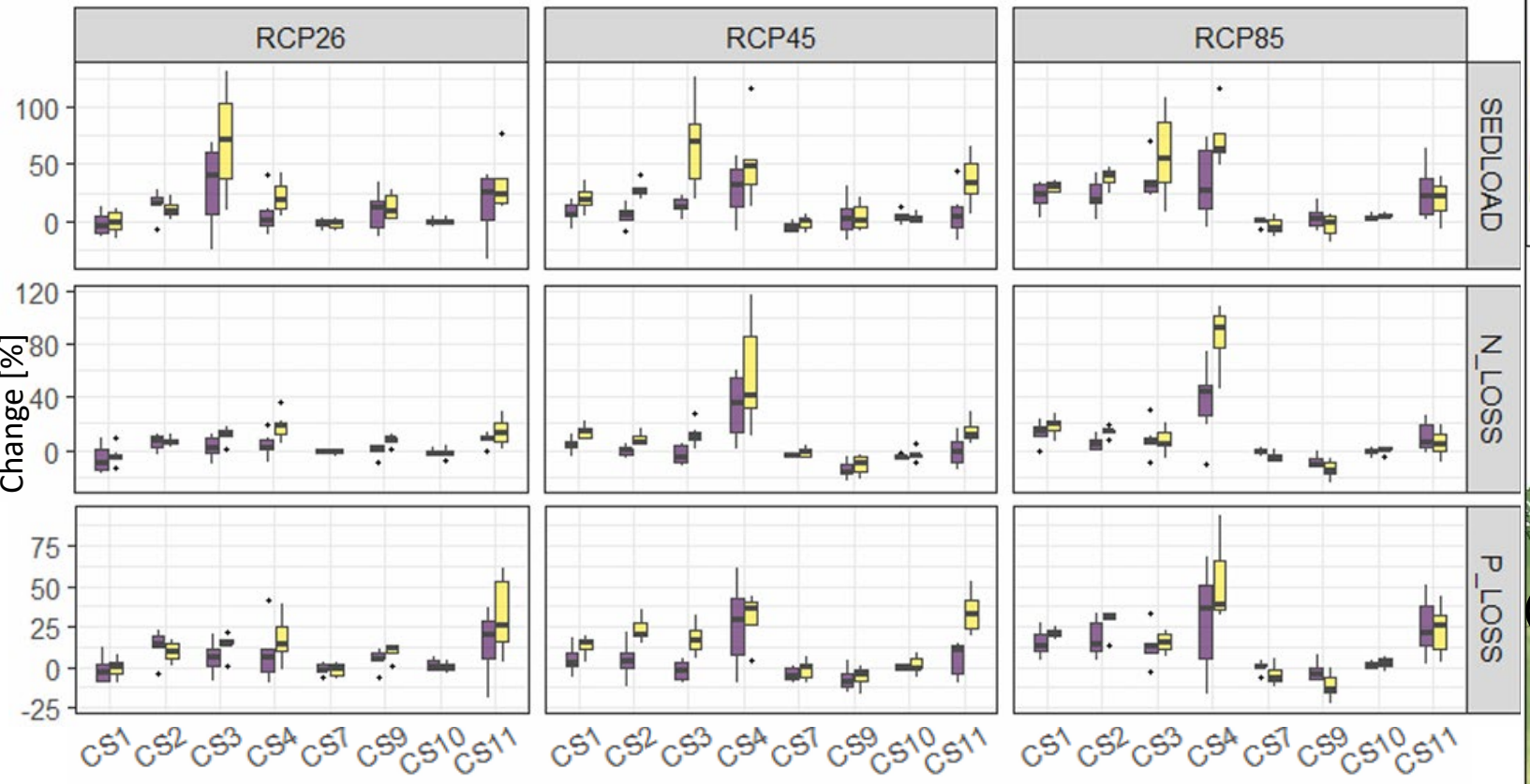
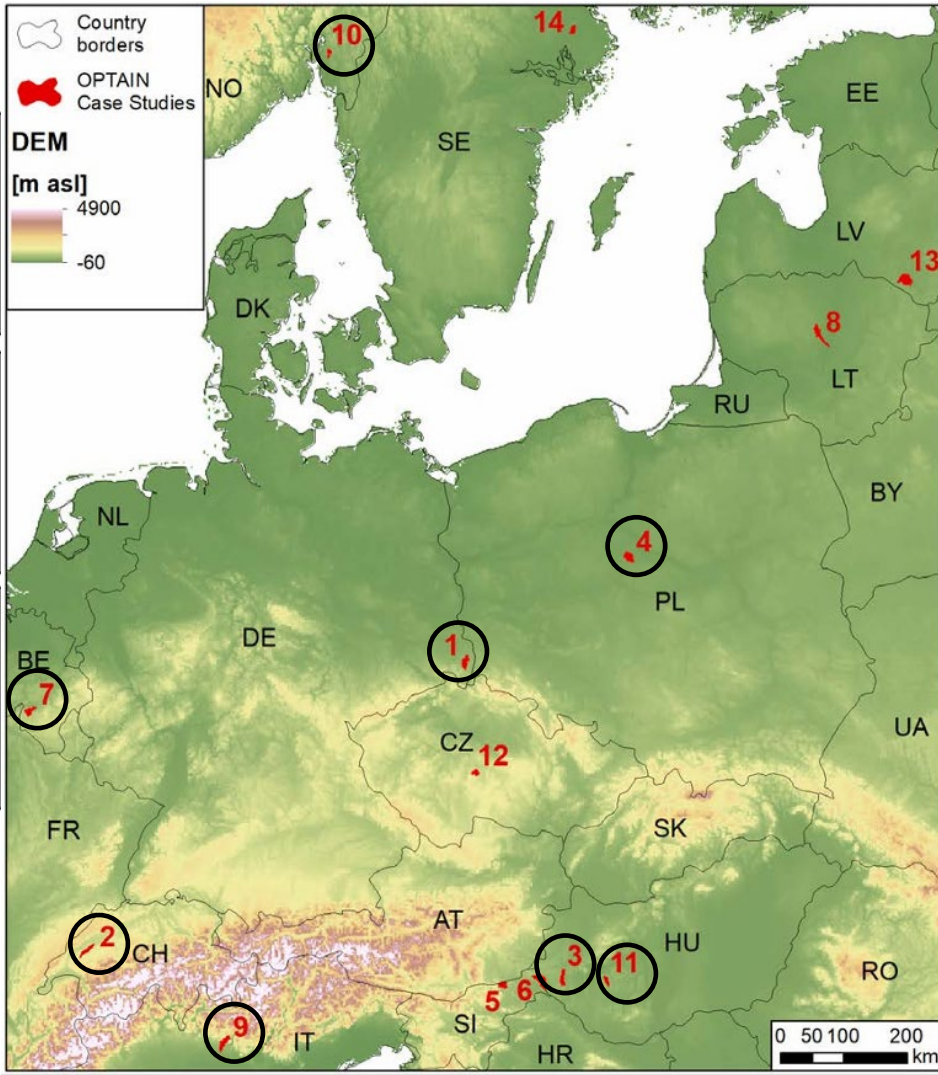
Climate change effects on sediment and nutrient losses





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Preliminary qualitative screening of NSWRM effectiveness

		DE	HU	PL	BE	IT	NO	HU
NSWRM	Type of change	CS1	CS3	CS4	CS7	CS9*	CS10	CS11
Afforestation	Land cover			N P				W
Riparian buffers	Land cover		W P		N P			P
Floodplain restoration	Land cover							
Grassed waterways	Land cover	N P					W	
Hedges	Land cover							
Cover crops	Crop mgt.			N				
Drought-resistant plants	Crop mgt.							
Low tillage	Soil mgt.						W N	
Low tillage + cover crops	Crop & soil mgt.	W P						
No tillage	Soil mgt.		W N P					W P
Terracing	Land morphology							
Controlled drainage	Art. impoundment							
Channel restoration	Art. impoundment					W		
Detention ponds	Art. impoundment			N P		W		
Wetlands	Art. impoundment							
Combined**	Depends on comb.	W N P	W N P	N P	N P	W	W N	W P

Legend

Black => NSWRM has been modelled

W – effectiveness in water retention

N – effectiveness in N retention

P – effectiveness in P retention

Note: the results strongly depend on the scale of NSWRM application – that was not harmonised ☺

Final remarks

Harmonisation comes at a cost => high demand for support from less experienced modellers

Scaling up? Possible, but major effort needed for land object layer preparation (SWATbuildR input)

In-depth spatial analysis of model results revealed possible SWAT+ issues (e.g. very high N losses from forests)

Ongoing task: where to place which measures to maximise multiple benefits (CoMOLA)

If you want to find out more about OPTAIN results during the conference…

Name	Focus	Session
Michael Strauch	**Effectiveness** of NSWRMs in a German CS	A2 (Wed 10:50)
Péter Braun	Climate change **effects** on hydrology and crops in a Hungarian CS	A2 (Wed 11:10)
Enrico Chiaradia	**Effectiveness** of NSWRMs in a Italian CS	Poster (Wed 16:30)
Christoph Schürz	New **tool** for automated implementation of NSWRMs in SWAT+ model setups: SWATmeasR	F1 (Thu 13:30)
Svajunas Plunge	New **tool** supporting SWAT+ calibration: SWATtunR	F1 (Thu 13:50)
Piroska Kassai	**Effectiveness** of NSWRMs in a Hungarian CS	F1 (Thu 14:10)
Brigitta Szabó	Improving soil input **data** for environmental modeling	F1 (Thu 14:30)

Invitation to the OPTAIN webinar on modeling water and nutrient retention measures

Wednesday, 3 September, 15:00-17:00 CET

Topics: overview of developed tools, example results, Q&A

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Further resources

OPTAIN zenodo (short url: **bit.ly/optain_zenodo**)

- Assessment of NSWRM effectiveness under current and future climate at the catchment scale
- SWAT+ modelling protocol for the assessment of NSWRMs in small agricultural catchments
- Derivation of soil physical and hydraulic properties (R script)
- Map topsoil phosphorus content (R script)

GitHub

biopsichas.github.io/SWATprepR

chrisschuerz.github.io/SWATfarmR

chrisschuerz.github.io/SWATrunR

biopsichas.github.io/SWATtunR/

UFZ GitLab

git.ufz.de/schuerz/swatdoctr

Thank you to OPTAIN modellers!

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Thank you!

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