OPTAIN

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

Harmonized SWAT+ modeling workflows in R

An overview of R packages and workflows for input data preparation, model setup, model verification and calibration

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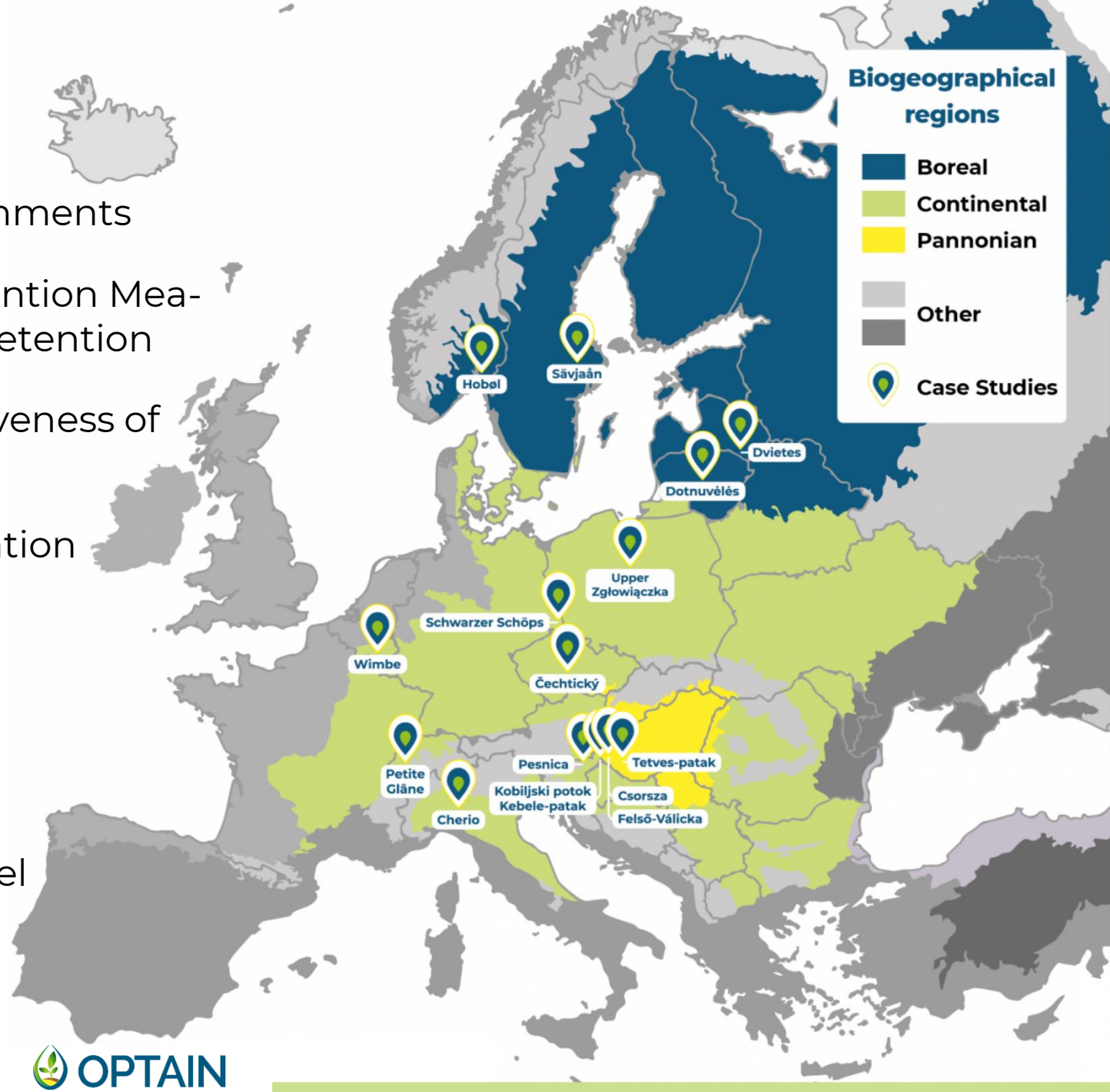
UFZ HELMHOLTZ Centre for Environmental Research

SWAT+ modelling in OPTAIN

- 14 case studies in small agricultural catchments
- Assessment of Natural/Small Water Retention Measures (NSWRMs) on water and nutrient retention
- Delineate general insights on the effectiveness of NSWRMs
- Synthesize guideline for the implementation of NSWRMs for
  - European agricultural catchments
  - across 3 biogeographical regions

↳ Establish harmonized approach for model setup, parametrization, calibration and NSWRM assessment across all sites



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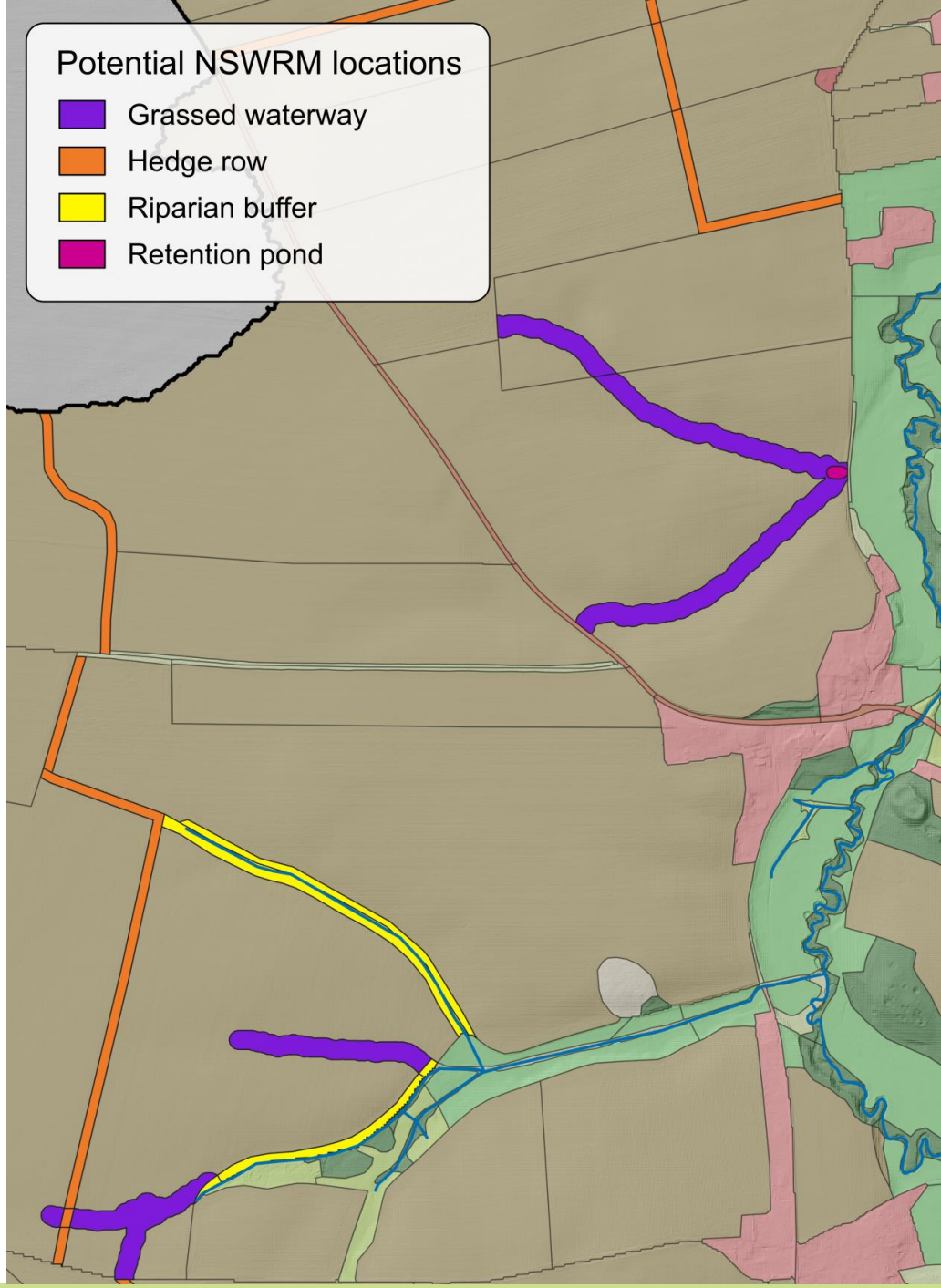
SWAT+ modelling in OPTAIN

- Simulate the local impact of NSWRMs and the combination of measures on the field scale
- Evaluate the sum of measures on aggregated catchment scale outputs
- Particularly the assessment of structural measures requires a detailed spatial representation in the landscape

↳ Make use of novel approach in SWAT+ to represent spatial hydrological objects and their connectivity

↳ Harmonize representation of landscape features and its parametrization across all case studies



package family

SWATprepR

SWAT+ input data preparation

SWATbuildR

An object connectivity
based SWAT+ model builder

SWATfarmR

Simple rule based management
operation scheduling

SWATdoctR

Model diagnostics tool
for SWAT+ model setups

SWATrunR (fka SWATplusR)

Running SWAT simulations in R

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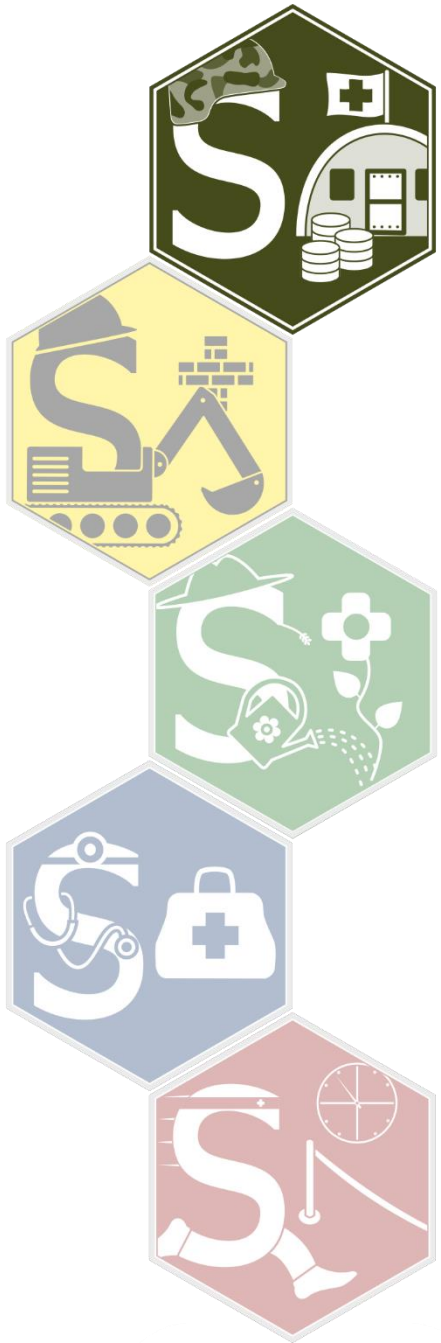

SWATprepR

SWAT+ input data preparation

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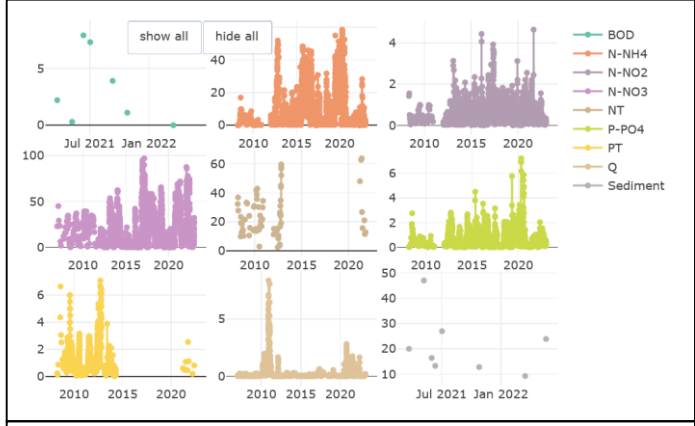
SWATprepR

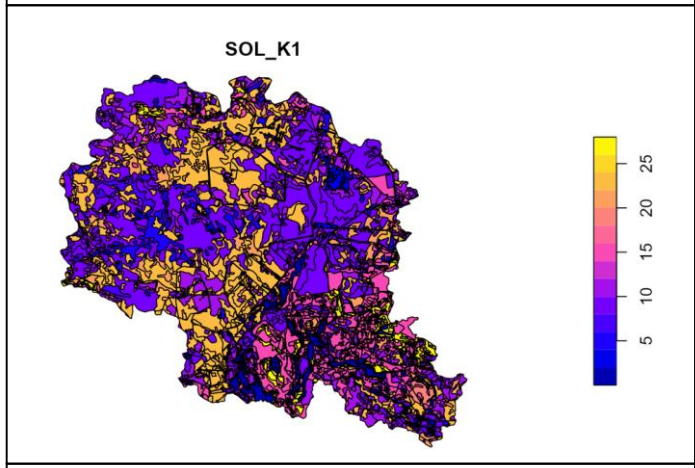
SWAT+ input data preparation

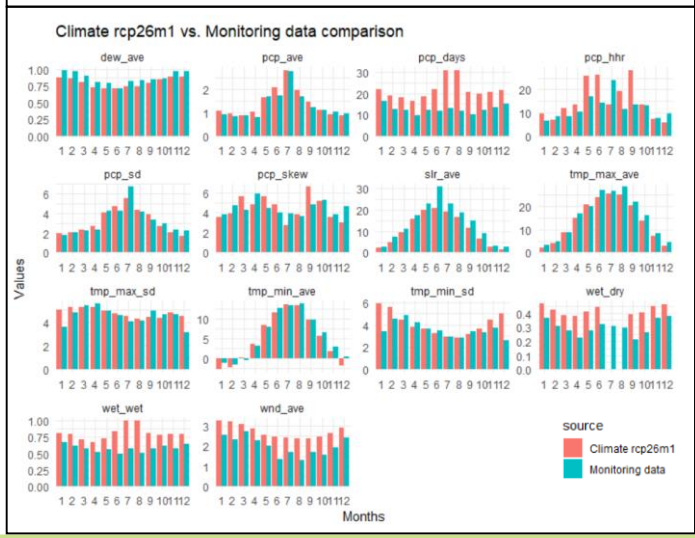
- Preparation, cleaning and visualization of observation data
- Extraction and preparation of EMEP data as atmospheric deposition input for SWAT model setup
- Preparation, estimation, and visualization of soil data
- Preparation and analysis of weather data, weather generator and climate projections

Session D3 Thu 10:00 – 10:20

Svajūnas Plungė: SWAT+ input data preparation in a scripted workflow - SWATprepR







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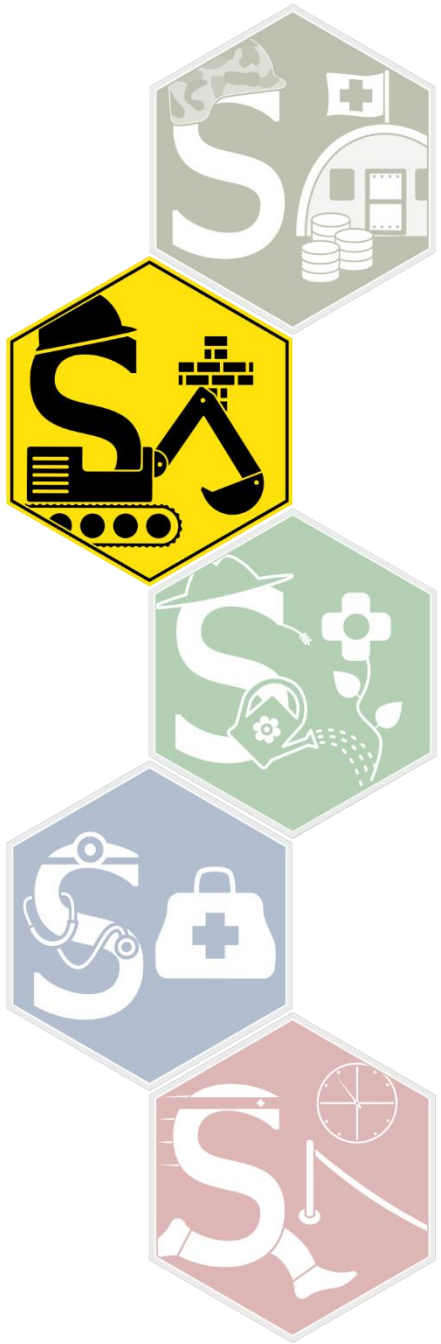
SWATbuildR

An object connectivity
based SWAT+ model builder



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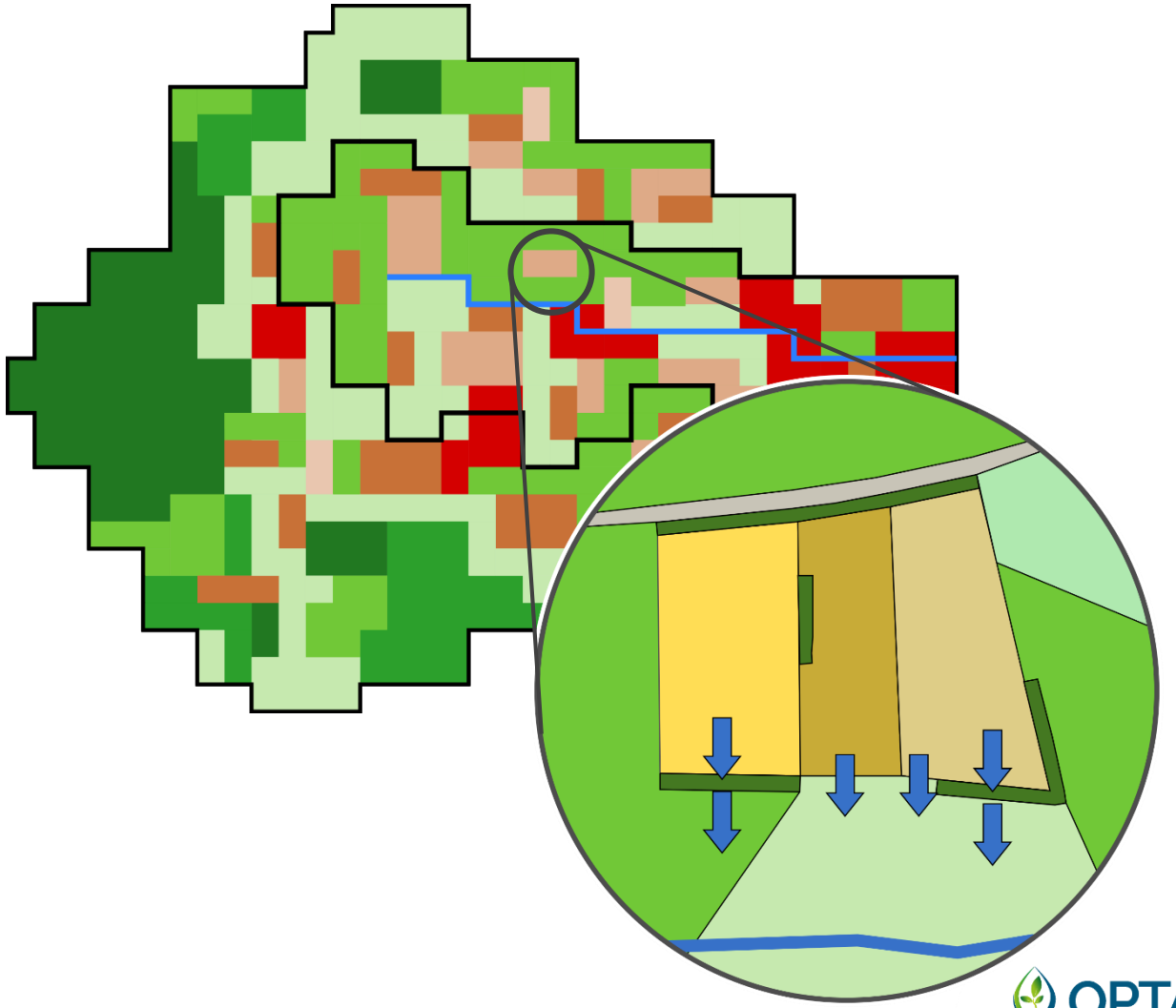
SWATbuildR

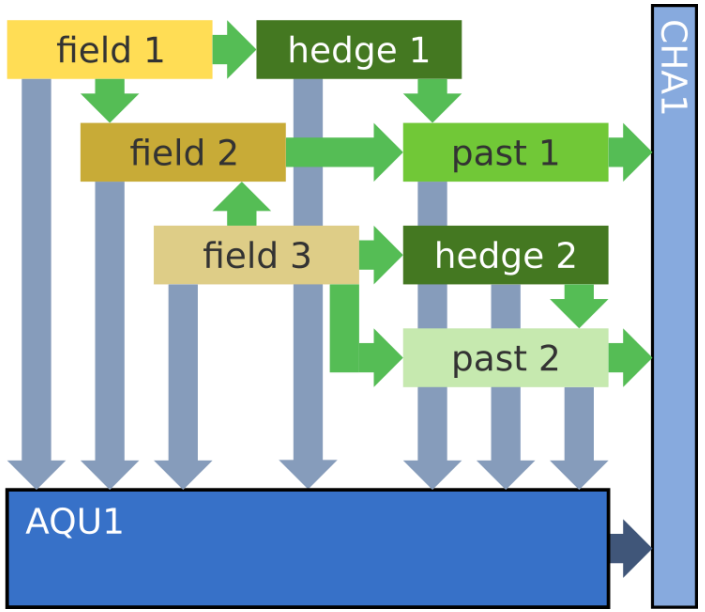
An object connectivity based SWAT+ model builder

Contiguous object connectivity - Flexible connectivity between all spatial objects



Contiguous object:

- Self-contained spatial unit
- Defined border with neighbor objects



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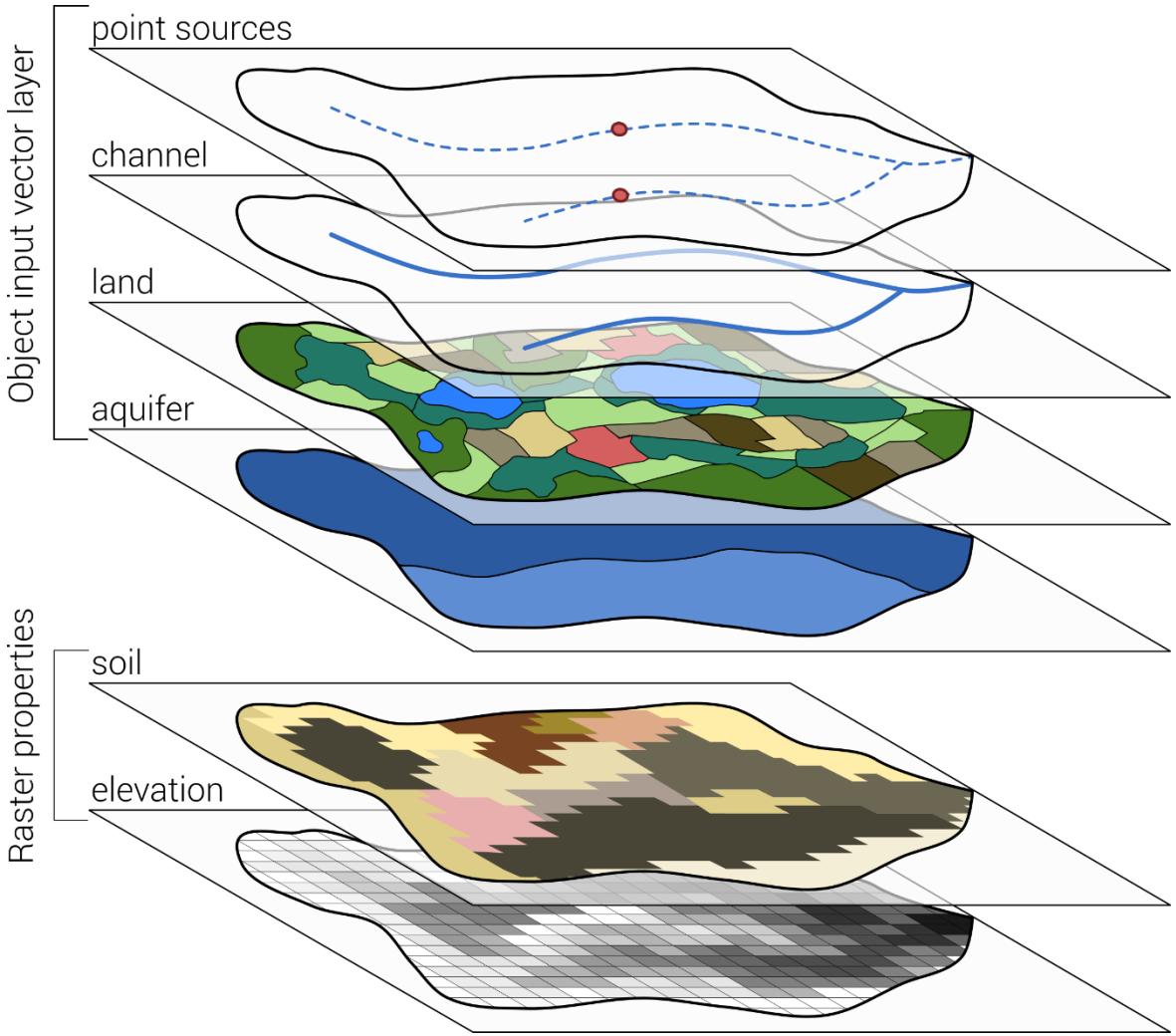
Concept model builder - Input layers organize spatial objects



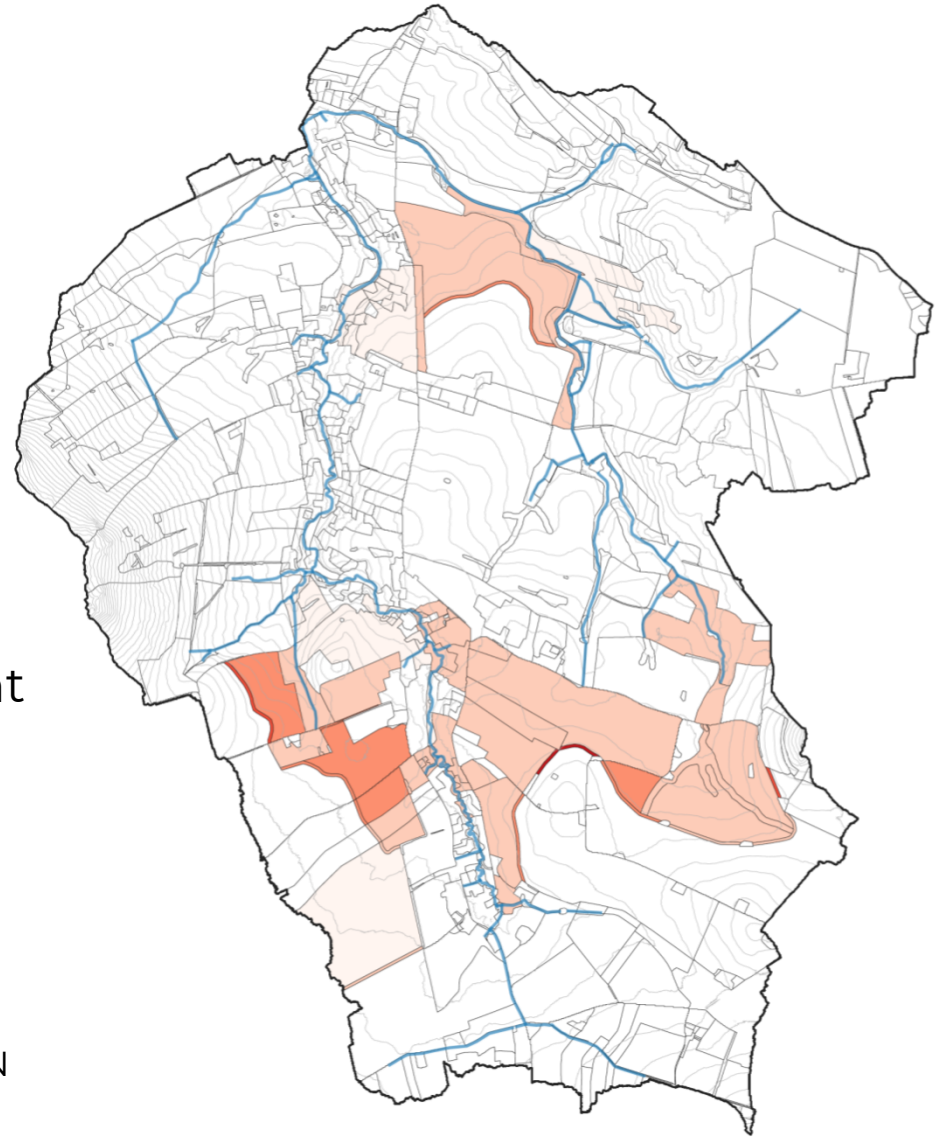
- Spatial objects are organized in vector layers
- Each polygon in the input layers will be a unique object in the SWAT+ model setup
- Land object connectivity derived from terrain
- Water connectivity given by direction and connection of water objects
- Dominant soil is assigned to land units

SWATbuildR

An object connectivity based SWAT+ model builder

Lessons learnt so far

- Script based model setup procedure developed and tested
- SWATbuildR routine employed in model setup of almost all OPTAIN case studies
  - Preparation of input layers extremely time consuming
  - Setup process highly sensitive to errors in input data
  - Requires substantial processing and several iterations
- Potential issues for simulated processes when water/nutrient fluxes occur between objects with great size difference
- First tests of implemented NSWRMs show promising results



Session A4 Wed 11:10 – 11:30

Michael Strauch: Assessing the impact of water and nutrient retention measures using a contiguous object connectivity approach: Insights from the German OPTAIN case study

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SWATfarmR

Simple rule based management operation scheduling

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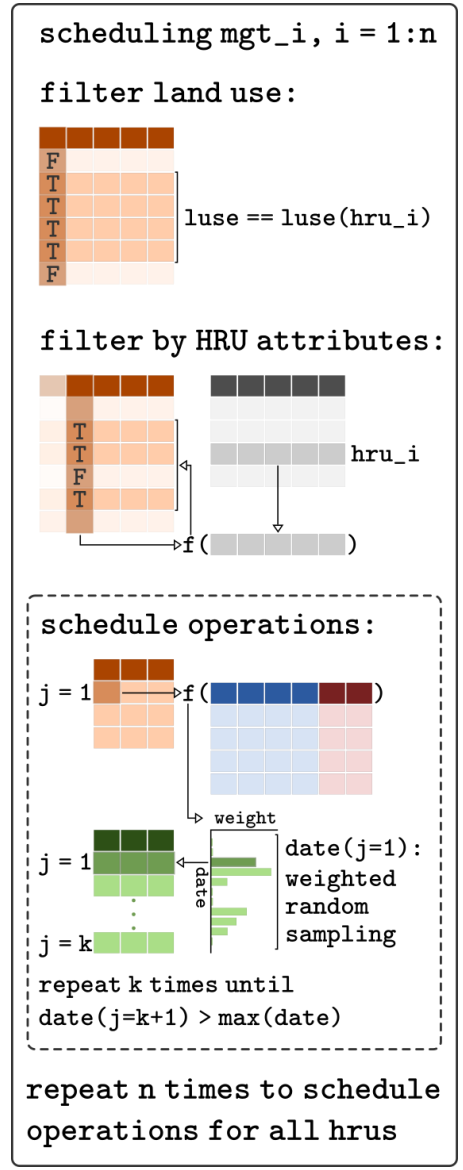
SWATfarmR

Simple rule based management operation scheduling

- Pre-processing tool to define dates for management operations
- User defines management sequences for all land uses and rules to trigger the individual operations
- Rules can include HRU attributes (e.g. slope or soil type) and temporal variables (e.g. precipitation, temperature), but no model states!
- Obsolete because of SWAT+ decision tables?



SWATfarmR

Simple rule based management operation scheduling

land_use
lu1_lum
lu1_lum
lu1_lum
lu1_lum
lu2_lum
lu2_lum
lu3_lum

land use of hru_i is lu1_lum
land_use == land_use(hru_i)

management	weight
conservation	0.55
conventional	0.45

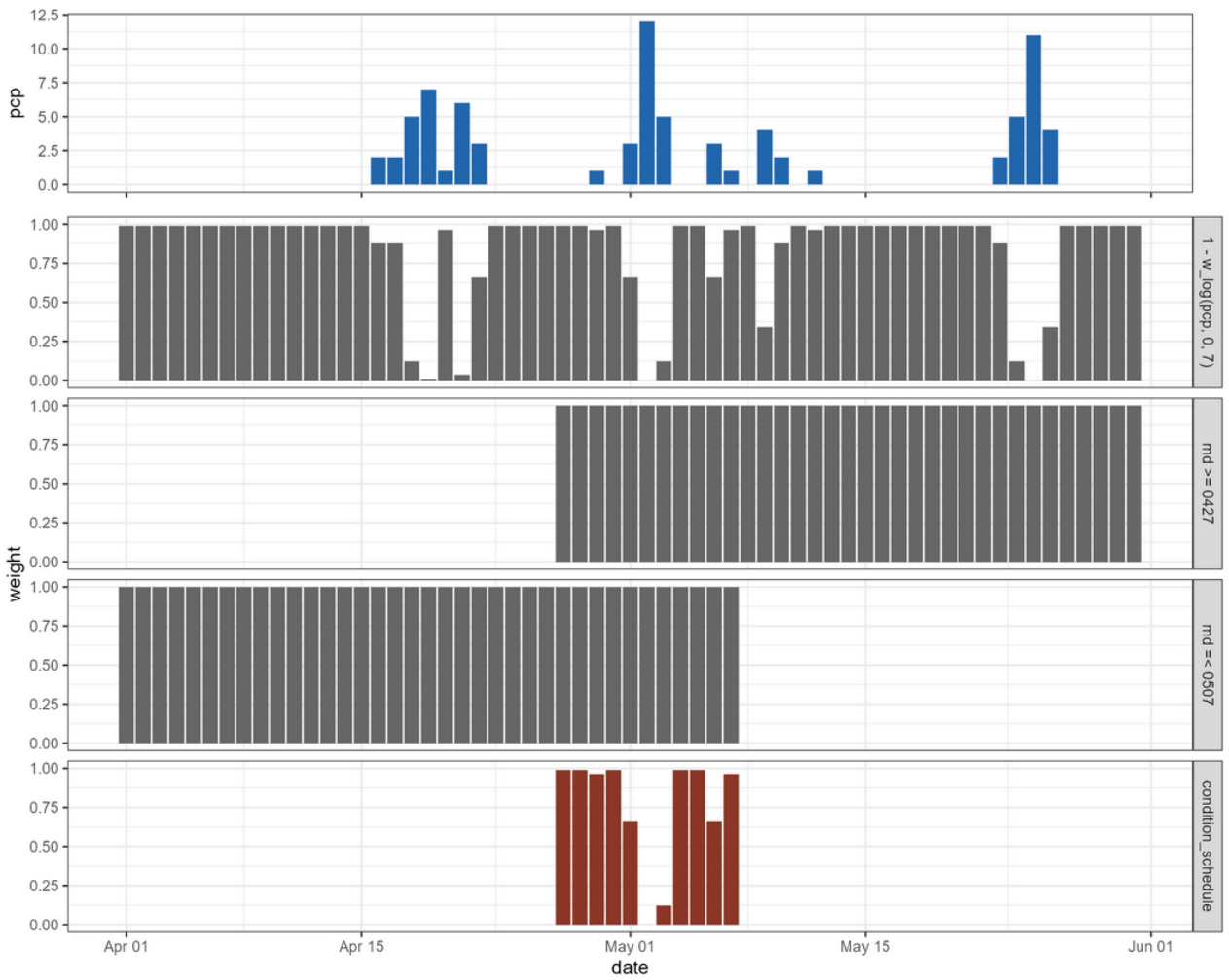
weighted random sampling
selected:
management == 'conventional'

filter_attribute
slp >= 0.08
slp < 0.08

filter by HRU attributes
slope of hru_i is >= 0.08

condition_schedule	operation

```
(md >= 0427) * (md <= 0507) * (1 - w_log(pcp, 0, 7))
```



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SWATfarmR

Simple rule based management operation scheduling

Crop information (field-specific)

a) Local data → Generalize/ aggregate

b) Crop classification → SWATprepR `extract_rotation()`

***lu.shp** with crop sequence per field*

relevant crops

Crop management schedules

***mgt_crops.csv** with schedules for all crops*

Generic management schedules

***mgt_generic.csv** with schedules for generic land use*

SWATprepR

`get_usersoil_table()` → usersoils.csv

`prepare_wgn()` `add_weather()`

SWATfarmR input generator

(R script workflow)

farmR_input.csv

SWATbuildR → ***.sqlite***

SWAT+Editor → ***txtinout***

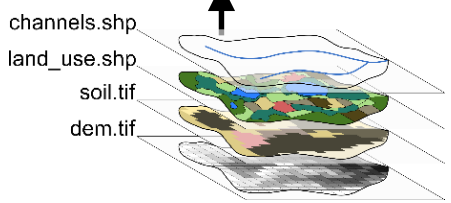
Update txtinout

(R script workflow)

***Update** landuse.lum, plants.plt, fertilizer.frt, tillage.til, soil_plant.ini, nutrients.sol, hru-data.hru*

SWATfarmR → ***Update of txtinout***

(management.sch, plant.ini, hru-data. hru, landuse.lum, time.sim, file.cio)



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SWATdoctR

Model diagnostics tool
for SWAT+ model setups

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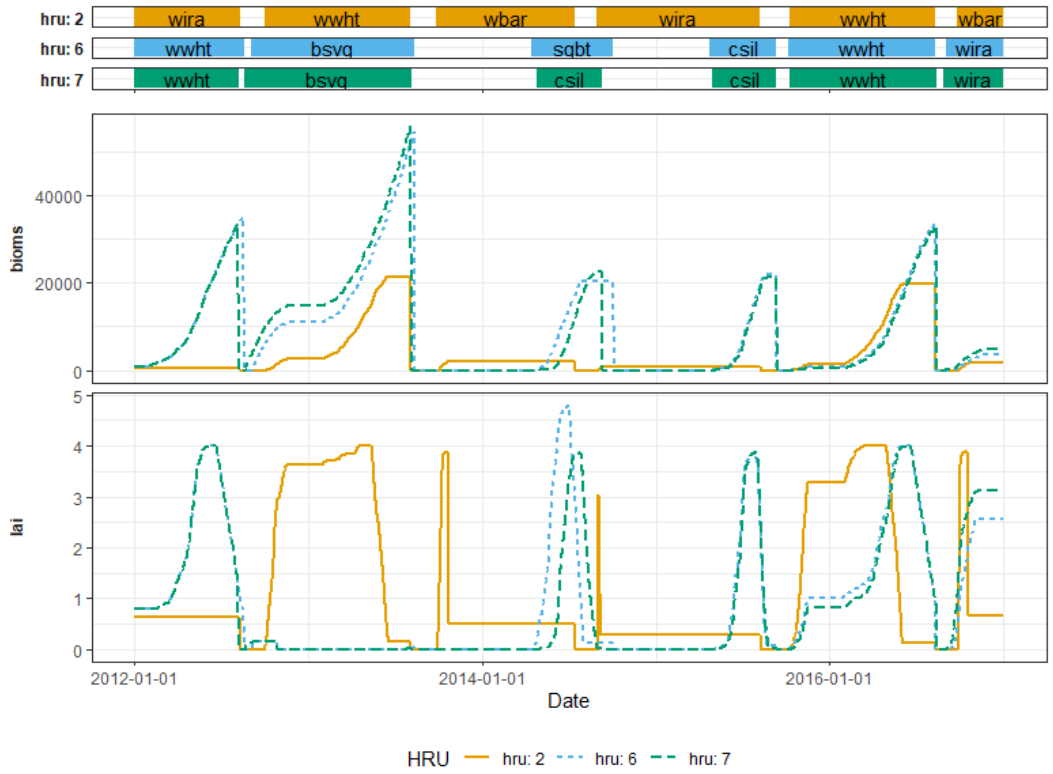
SWATdoctR

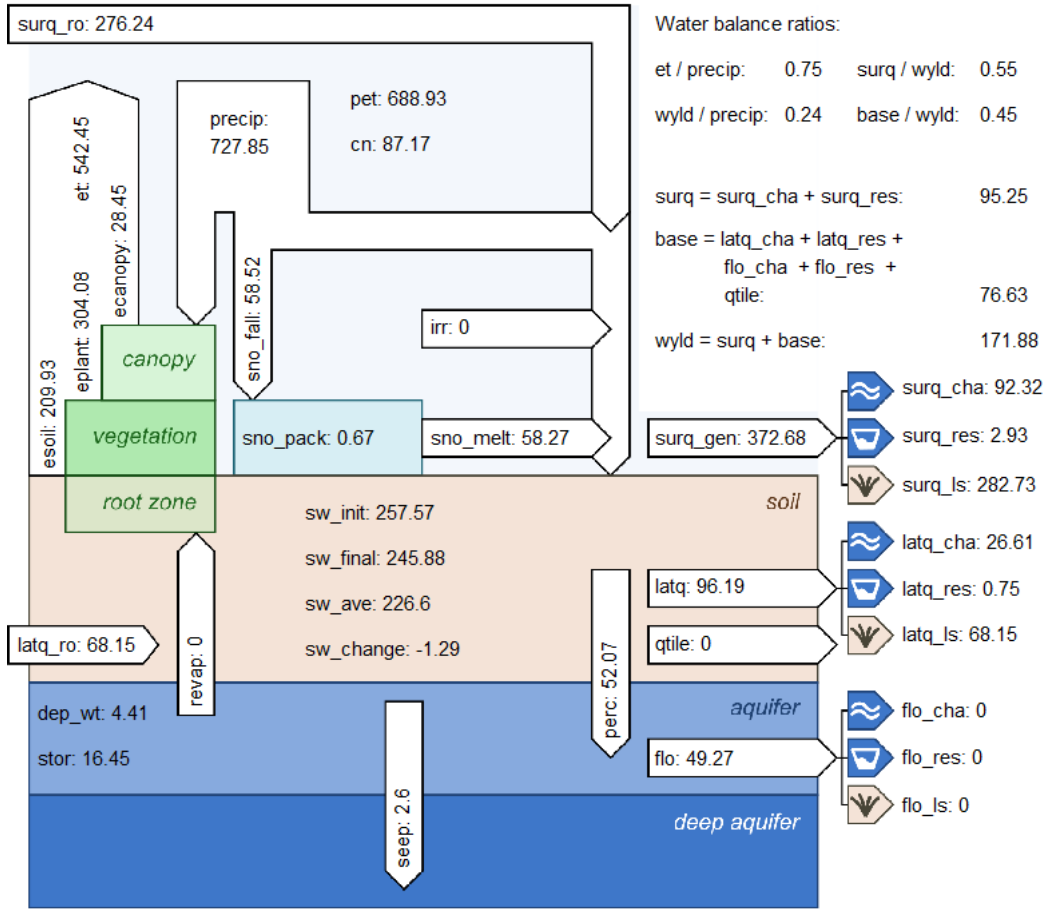
Model diagnostics tool for SWAT+ model setups

- Tools to investigate model setups
- Detect potential issues in model setups at an early stage

Session G2 Fri 09:40 – 10:00

Svajūnas Plungė: SWAT+ model setup verification tool: SWATdoctR





SWATrunR

Running SWAT simulations in R

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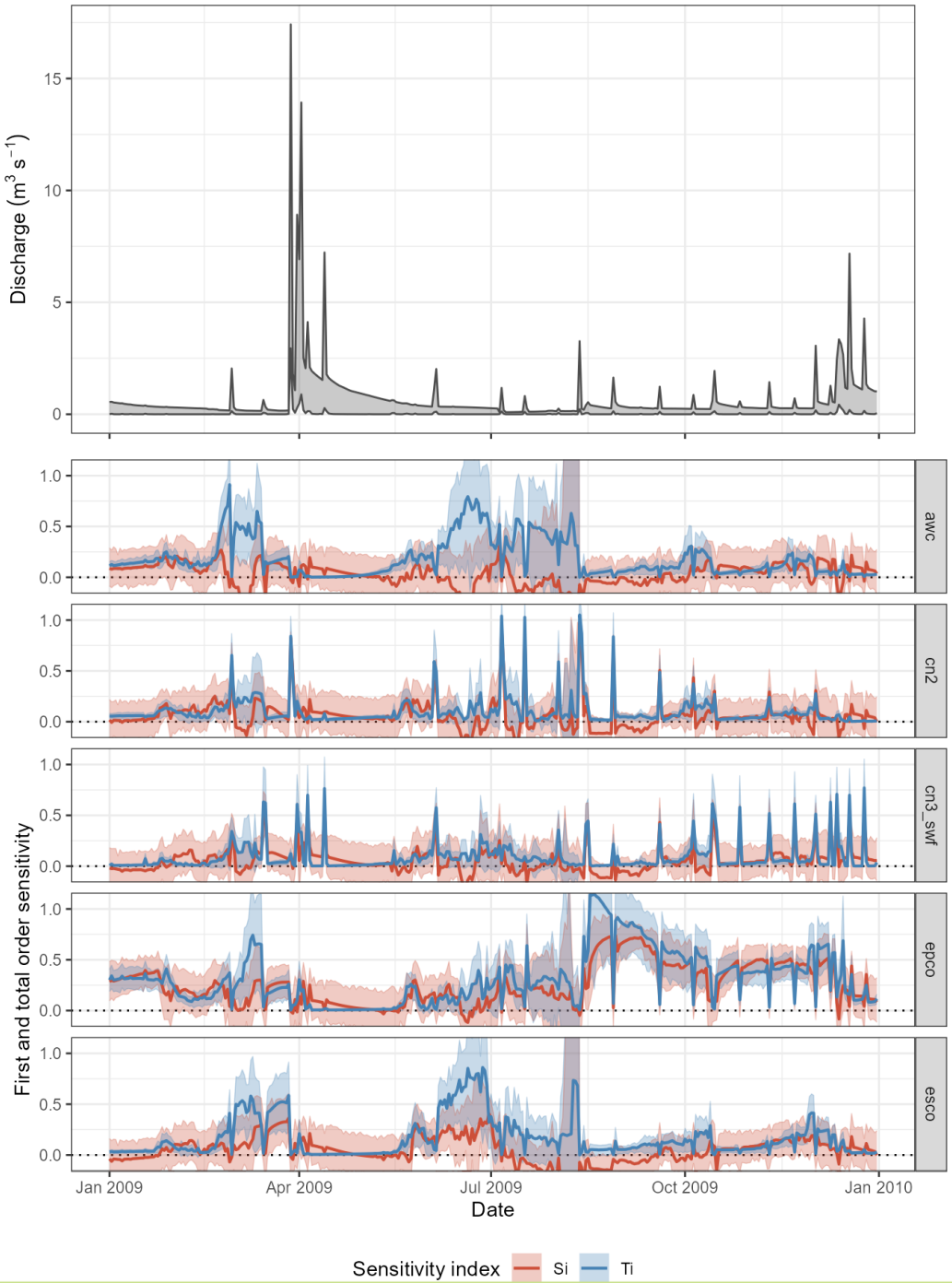
SWATrunR

Running SWAT simulations in R

- One major function: run simulations (with/without parameter changes) and return output variables in a tidy format
- Can be easily integrated in advanced workflows (sensitivity analysis, calibration, parameter optimization with other R packages)
- In OPTAIN workflow under development for model calibration



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Further resources

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

- **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

UFZ GitLab

git.ufz.de/schuerz/swatdoctr

Thank you!

Christoph Schürz

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