



Scuola Superiore Sant'Anna



2nd International LIFE REWAT Summer School

Digital water management and water-related agroecosystem services: geostatistics, hydroinformatics and groundwater flow numerical modelling

September 9th—20th, 2019
Scuola Superiore Sant'Anna
Pisa, Italy



2nd FREEWAT International Workshop

Modeling the hydrological impact of land use change in karst systems using the LuKARS plugin for FREEWAT

Daniel Bittner

Technical University of Munich, Germany



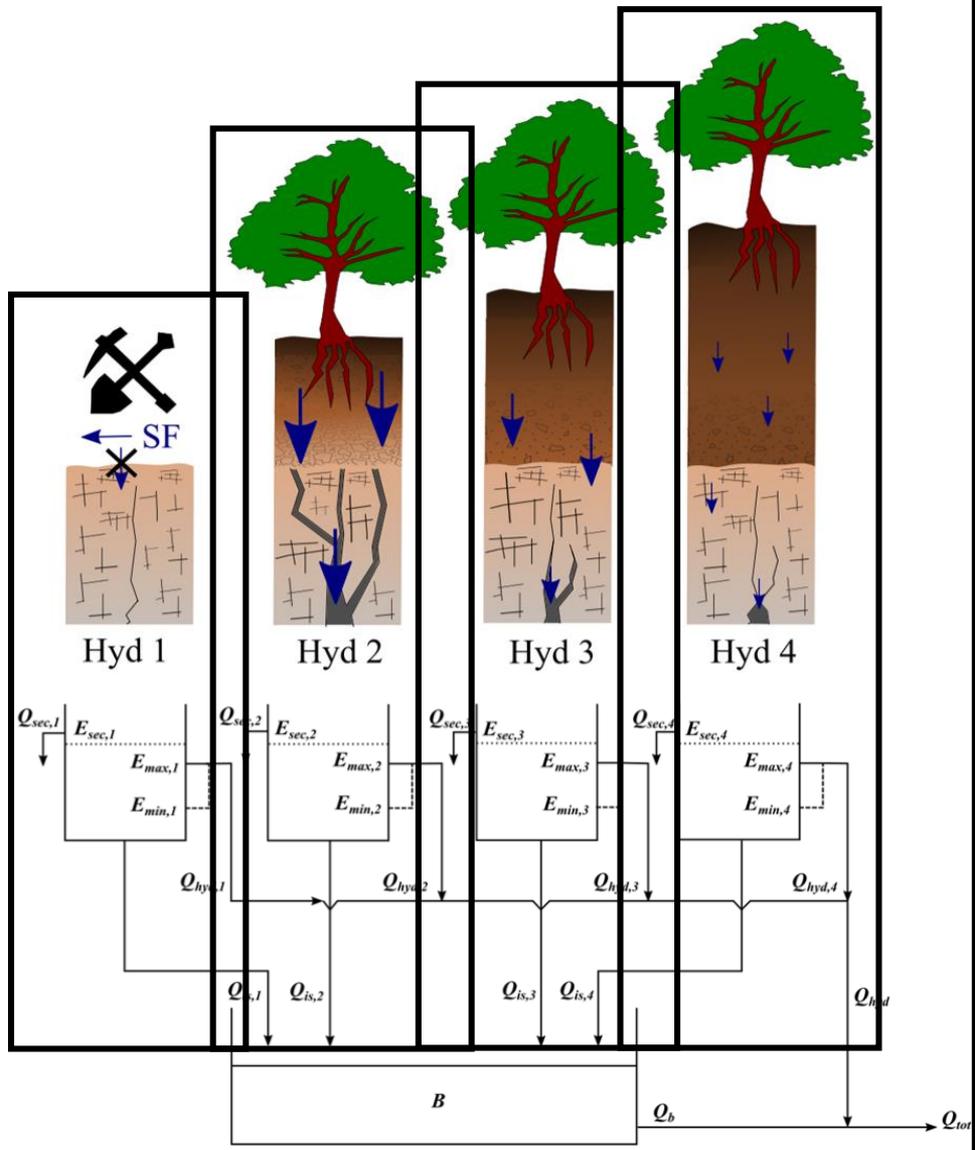
Modeling the hydrological impact of land use change in karst systems using the LuKARS plugin for FREEWAT

Daniel Bittner, Technical University of Munich,
Chair of Hydrology and River Basin Management

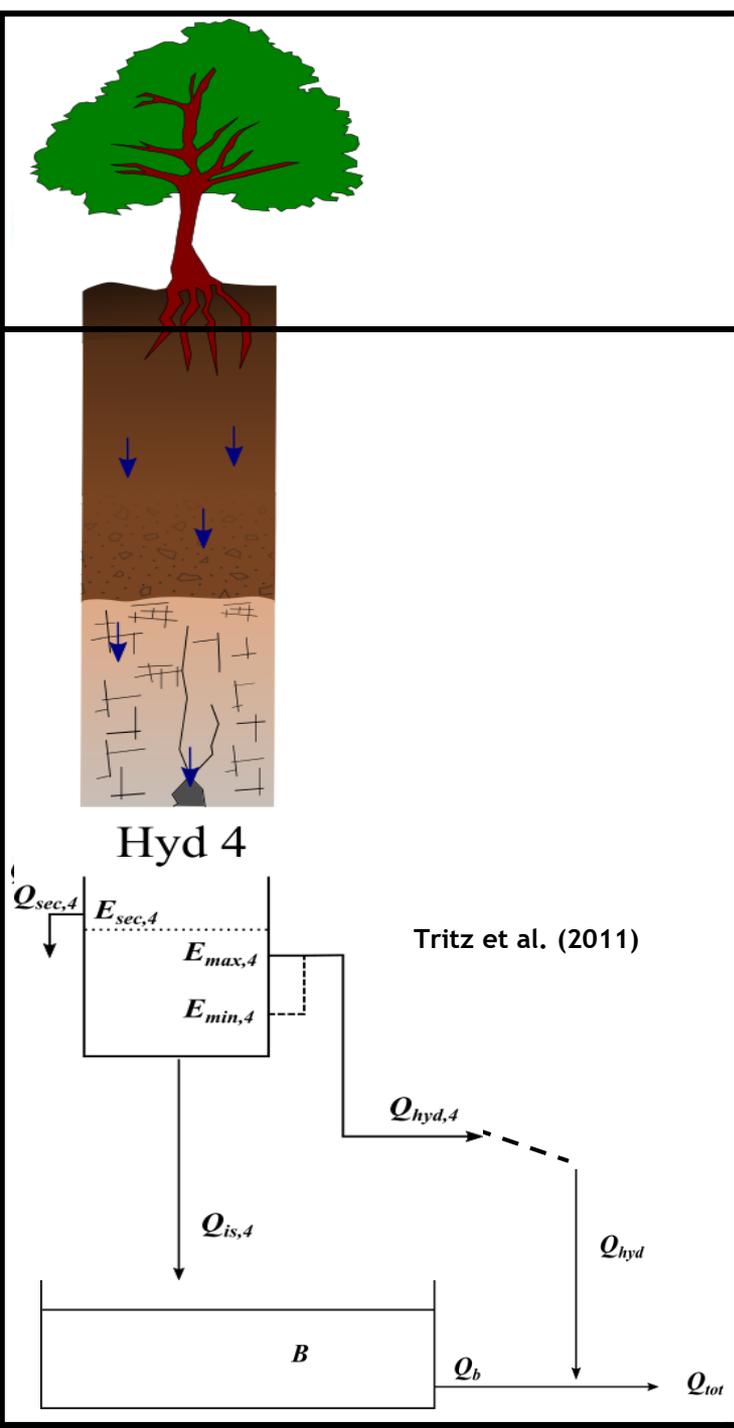
LuKARS - Land use change modeling in KARSt systems)

- Conceptual, semi-distributed modeling approach suggested by Bittner et al. (2018)
- Hydrotope-based (distinct landscape units characterized by homogeneous hydrological properties as a result of similar land use and soil types)
- Each hydrotope shows distinct hydrological responses to rainfall events depending on its soil properties
 - Separation of flows to gw recharge and quickflow
- Land use changes considered as changing hydrotope properties and/or varying evapotranspiration

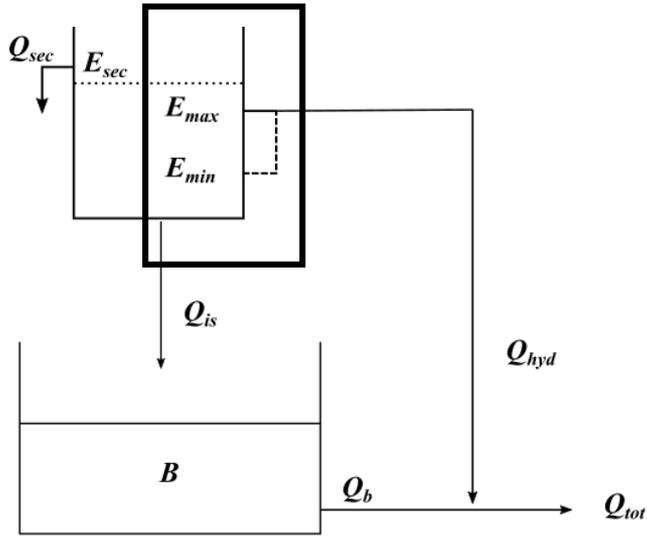
Model concept



Bittner et al. (2018)



Physically-based parameters



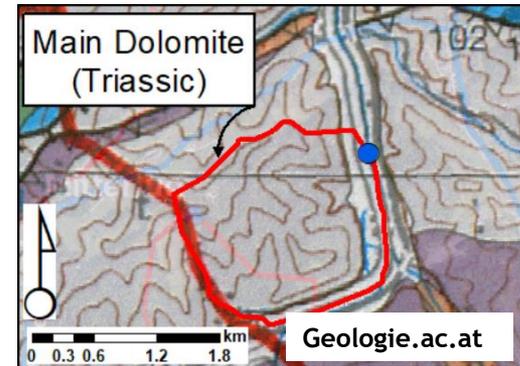
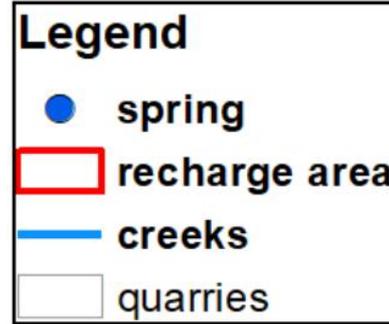
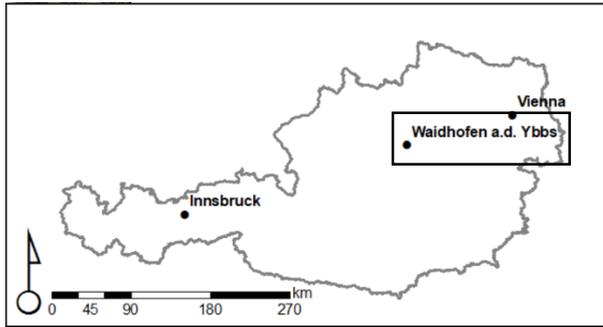
E_{min} , E_{max}

determined based on hydropedological fieldguide (DWA, 2019)

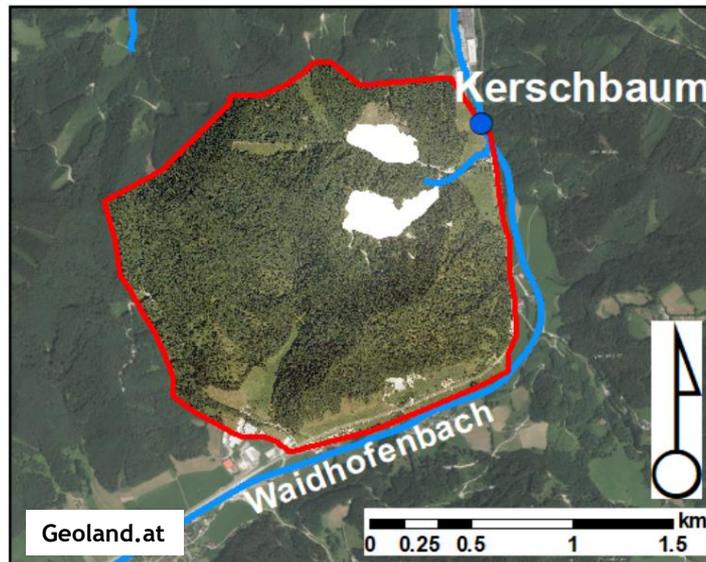
k_{hyd}

decreasing from high to low permeability

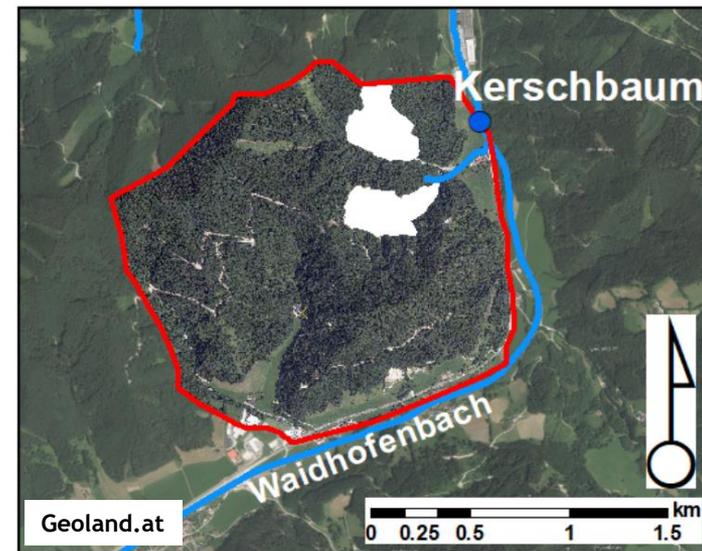
Case study



2007



2010 - 2013

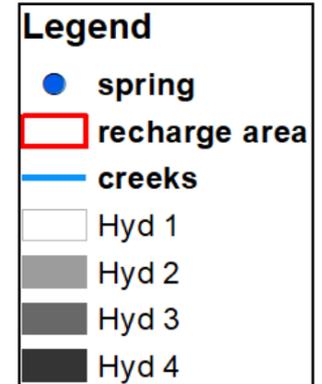


Case study

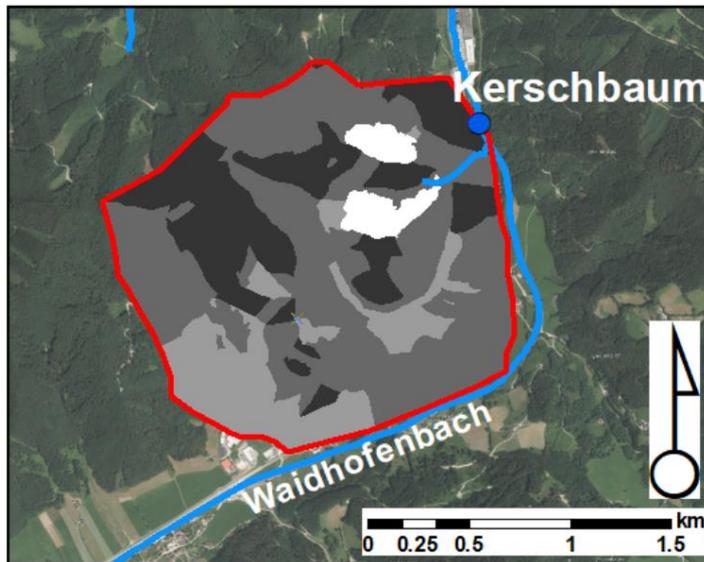
Required data:

Spatial data: detailed classification of the dominant hydrotopes in the recharge area

Time series: Q and P (optional: T and snow depth)



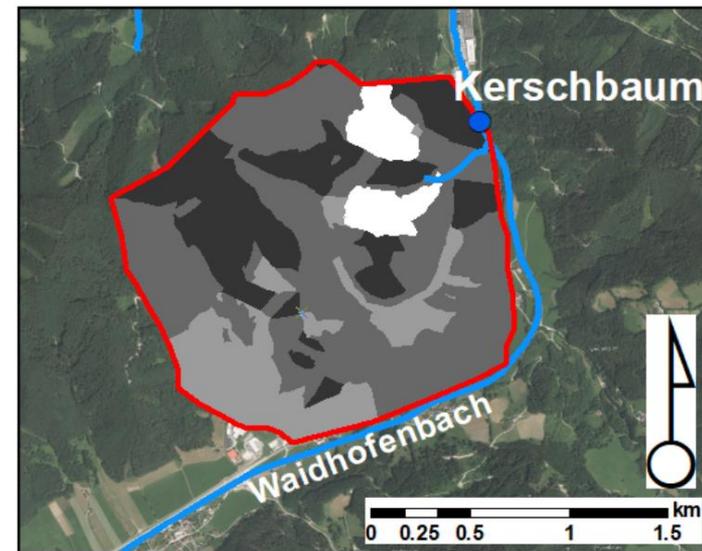
2007



Bittner et al. (2018)



2010 - 2013



Bittner et al. (2018)

Freewat implementation

QGIS 2.18.21 - farm

Projekt Bearbeiten Ansicht Layer Einstellungen Erweiterungen Vektor Raster Datenbank Web **FREEWAT** Verarbeitung Hilfe



- Data-Preprocessing (akvaGIS) >
 - Model Setup >
 - MODFLOW Boundary Conditions >
 - Solute Transport Process >
 - Water Management and Crop Modeling (FARM PROCESS) >
 - Calibration/Sensitivity >
 - Tools >
 - DataBase >
 - Post-processing >
 - OAT >
 - Land use change modeling in KARst systems (LuKARS) >**
 - About
- Run model

Dialog [?] [X]

Set-up model input Define parameters Hilfe

Set up LuKARS model

Take over sensors from OAT

Precipitation

Temperature

Discharge Q

Define hydrotopes Number of hydrotopes: 0

Input .shp hydrotope 1: hydrotope1

Input .shp hydrotope 2: hydrotope1

Input .shp hydrotope 3: hydrotope1

Input .shp hydrotope 4: hydrotope1

Snow Model		hyd	melt factor	melting threshold [°C]	hyd	interception threshold
<input type="radio"/> On	<input type="radio"/> Off	1	<input type="text"/>	<input type="text"/>	1	<input type="text"/>
Interception		2	<input type="text"/>	<input type="text"/>	2	<input type="text"/>
<input type="radio"/> On	<input type="radio"/> Off	3	<input type="text"/>	<input type="text"/>	3	<input type="text"/>
Evapotranspiration		4	<input type="text"/>	<input type="text"/>	4	<input type="text"/>
<input type="radio"/> On	<input type="radio"/> Off					

Warm-up period

from: 01.01.2000

to: 01.01.2000

Calibration period

from: 01.01.2000

to: 01.01.2000

Validation period

from: 01.01.2000

to: 01.01.2000

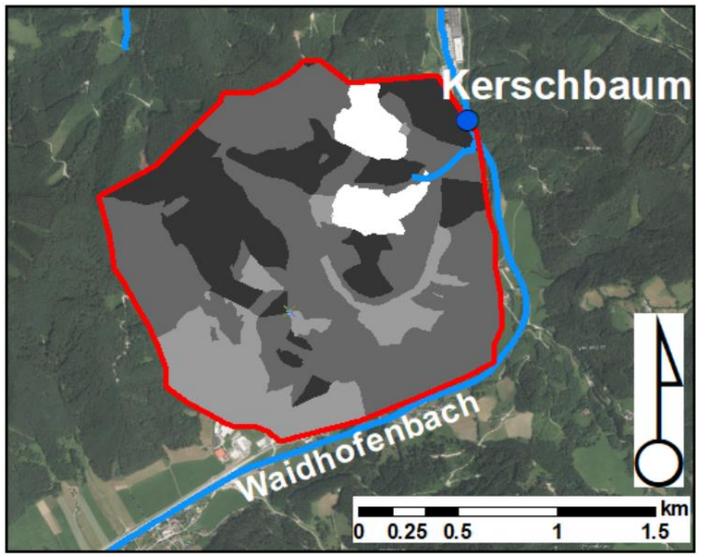
Prediction period

from: 01.01.2000

to: 01.01.2000

Check if valid input

Run Model Take hydrotopes on



Freewat implementation

The screenshot displays the Freewat software interface, specifically a dialog box titled "Dialog". The dialog has three tabs: "Set-up model input", "Define parameters", and "Hilfe". The "Hilfe" tab is active, showing help text under the heading "Buttons and related actions".

Buttons and related actions

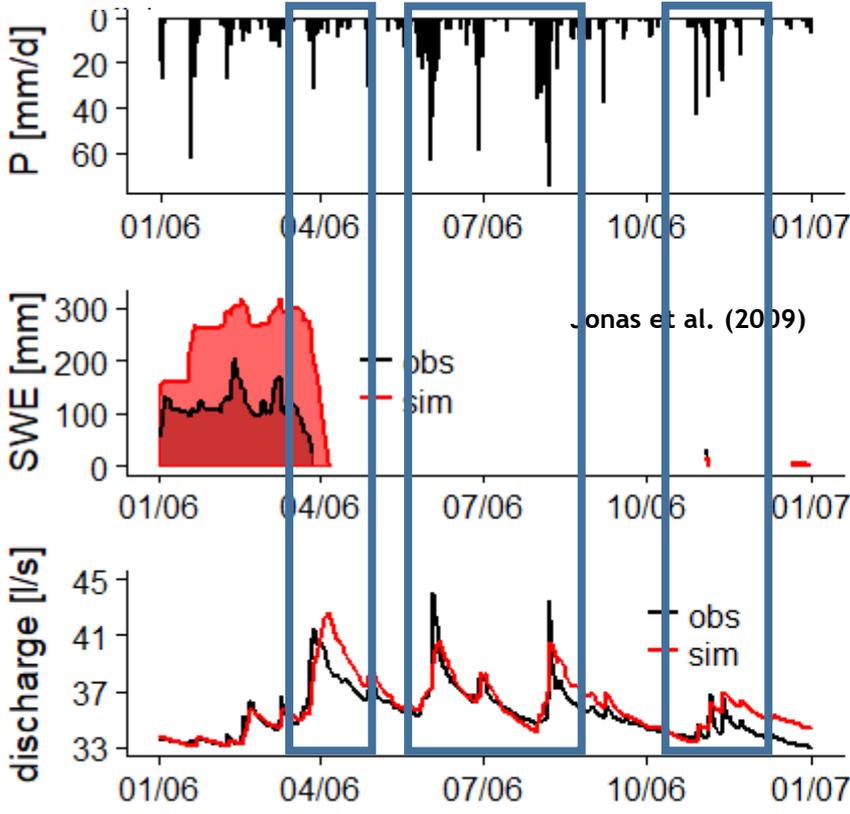
- Check if valid input:** Checks the inputs of the tab to avoid errors in the computing. Required to enable the tab in which the parameters are defined.
- Calibrate:** Runs the model, then opens a plot that shows measured discharge/time versus modelled discharge/time. Thereafter, these can be modified again by hand or automatically in order to obtain a model that is closer to measured discharge/time.
- Validate:** Runs the model, then opens a plot that shows measured discharge/time versus modelled discharge/time. A model is validated for checking if the calibrated model can be extrapolated and is still close enough to the measured discharge/time. Then, it can be used for predicting future discharges.
- Take hydrotopes on:** Adds parameters to the hydrotopes' attribute table for further modelling. This can be done without calibration or validation.
- Take parameters over from shapefile(s):** Reads parameters from attribute table of the hydrotope shapefile(s) and shows them in the input fields of the related parameter. Each parameter has have an own column in the attribute table and needs to have the same name as seen in the list where the parameters can be defined by hand.

Input hydrotopes

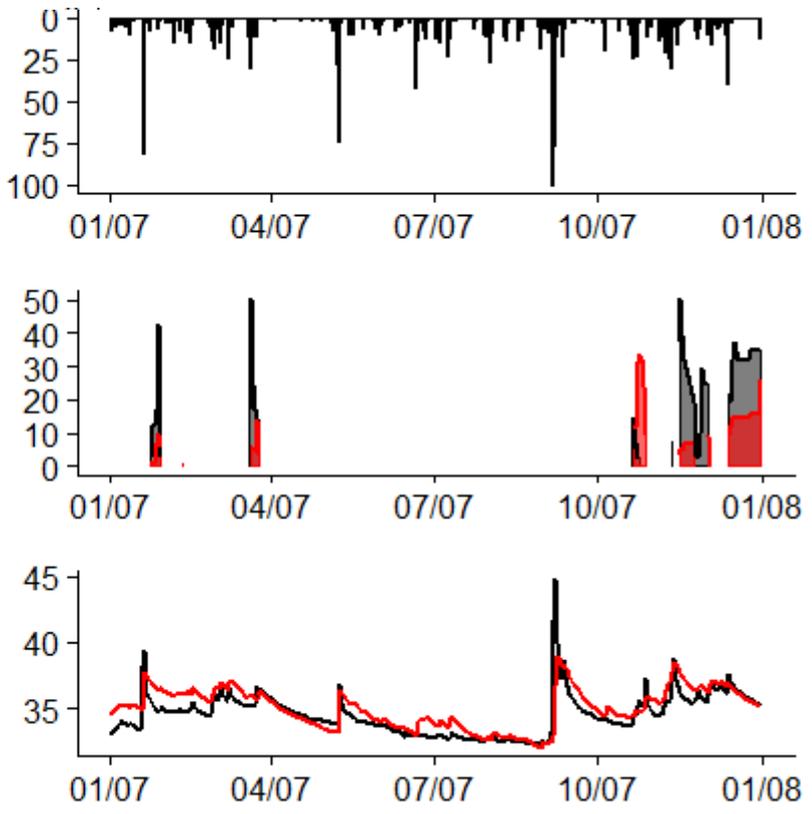
The dialog also features a table with three columns labeled "2", "3", and "4". Below the table is a "Load (optional)" button. At the bottom of the dialog, there are three buttons: "Run Model", "Take hydrotopes on", and "Run Model".

Red boxes highlight the "Hilfe" button, the table area, the "Load (optional)" button, and the three "Run Model" and "Take hydrotopes on" buttons at the bottom.

Modeling results

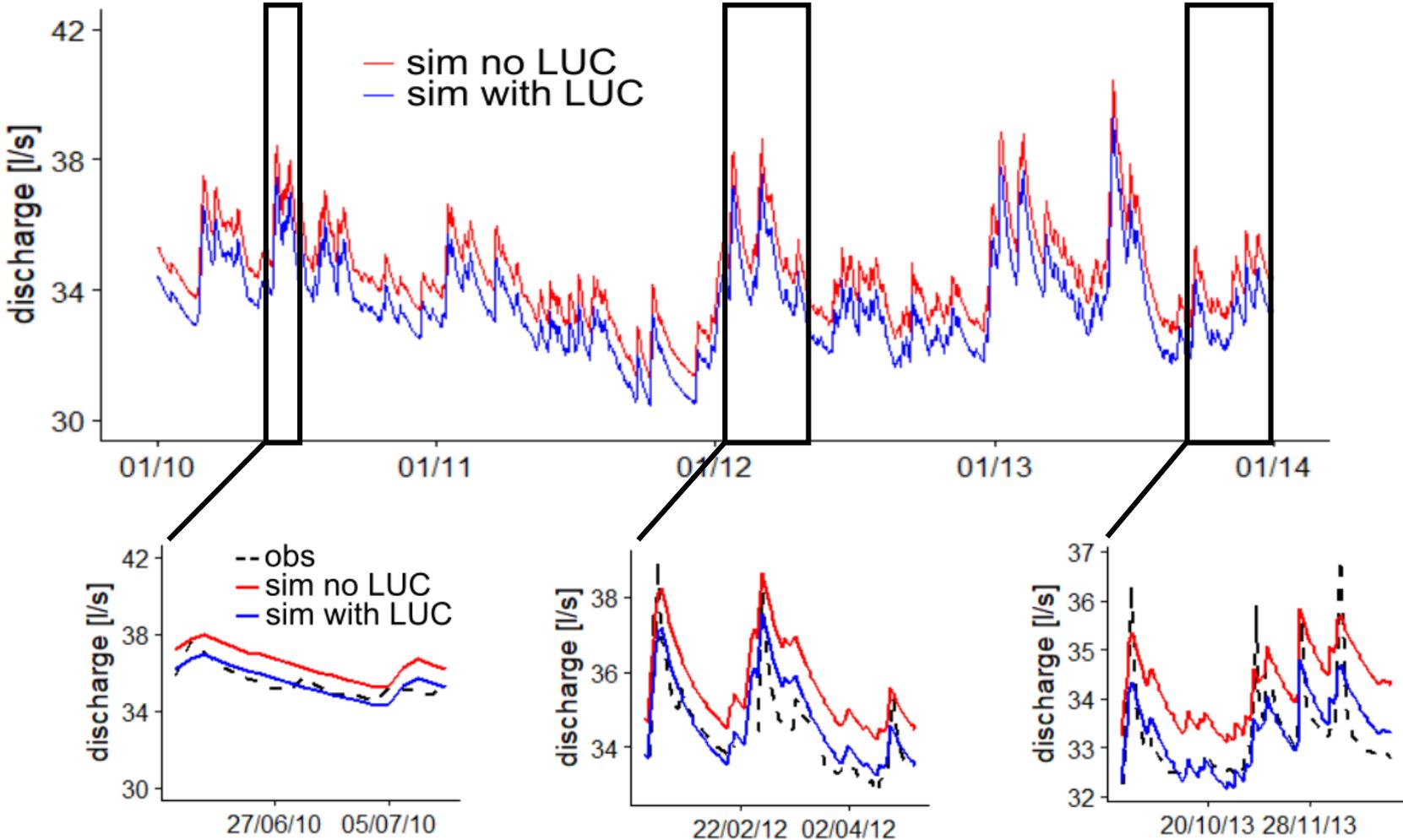


NSE: 0.66
MAE: 0.78 [l/s]



NSE: 0.53
MAE: 0.78 [l/s]

Modeling results



NSE	-1.1	0.65	-0.41	0.70	-0.78	0.58
MAE [l/s]	1.0	0.36	1.2	0.46	1.1	0.39

Open questions – next steps

- So far only diffuse recharge is considered – next step is to account for concentrated recharge as typical in (limestone) karst, ideas?
- Any important thing missing in FREEWAT implementation?
- Suggestions for further linking existing FREEWAT features with LuKARS?
- Any further ideas?

Thanks for your attention

LIFE REWAT project partners



LIFE REWAT project co-financers



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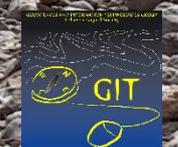


University of Applied Sciences and Arts of Southern Switzerland

SUPSI



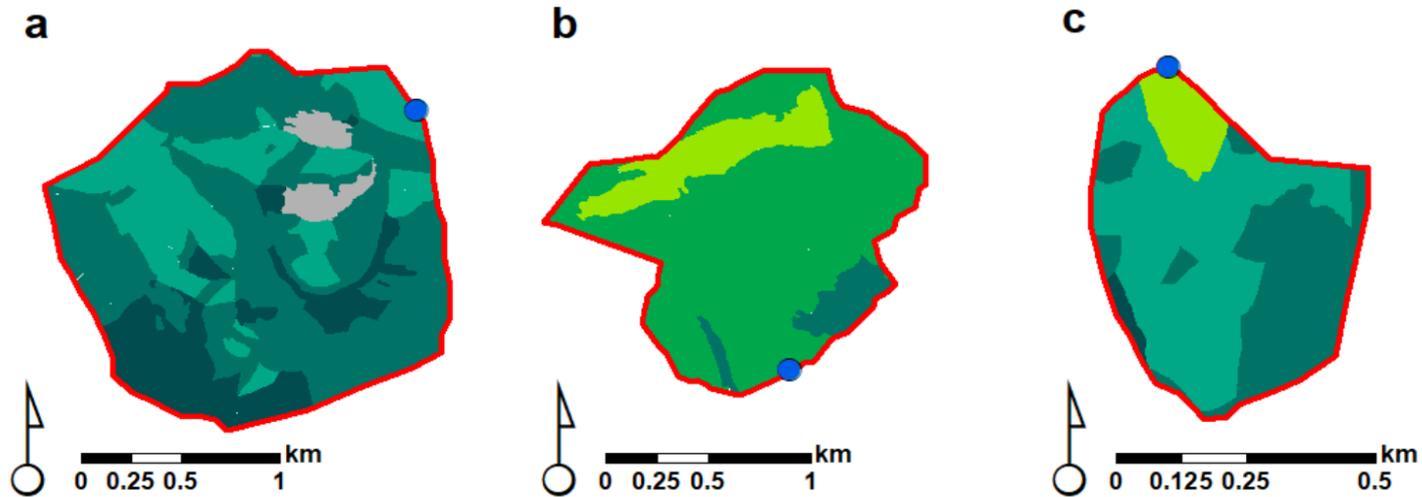
Patronage



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Hydrotopes in recharge areas



Legend

● springs □ catchments ■ Hyd Q ■ Hyd B1 ■ Hyd B2 ■ Hyd B3 ■ Hyd B4 ■ Hyd P

a → Kerschbaum
b → Hinterlug
c → Mitterlug

Hinterlug application

