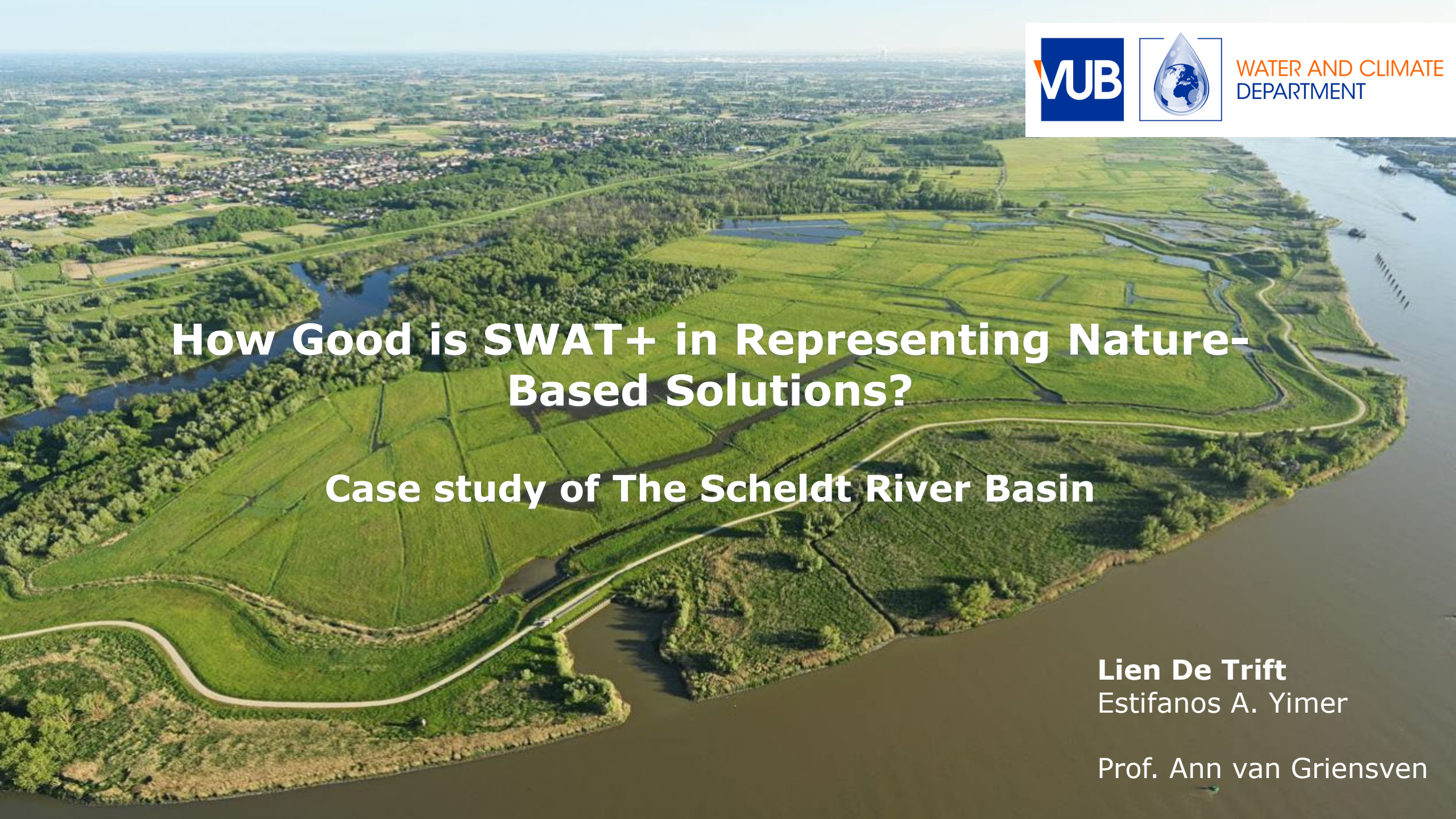


How Good is SWAT+ in Representing Nature-Based Solutions?

Case study of The Scheldt River Basin

Lien De Trift
Estifanos A. Yimer

Prof. Ann van Griensven

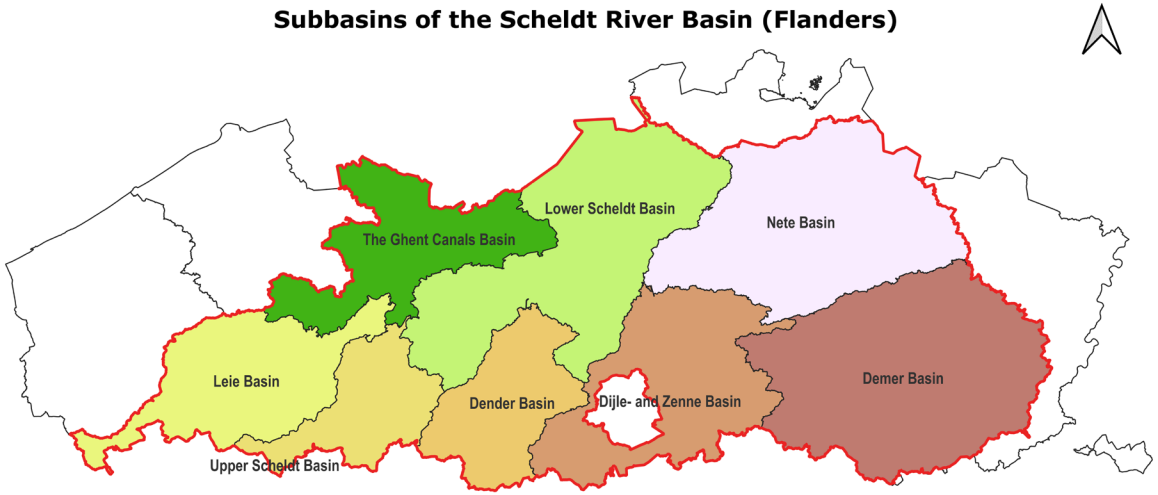
VUB WATER AND CLIMATE DEPARTMENT

THE SCHELDT RIVER BASIN

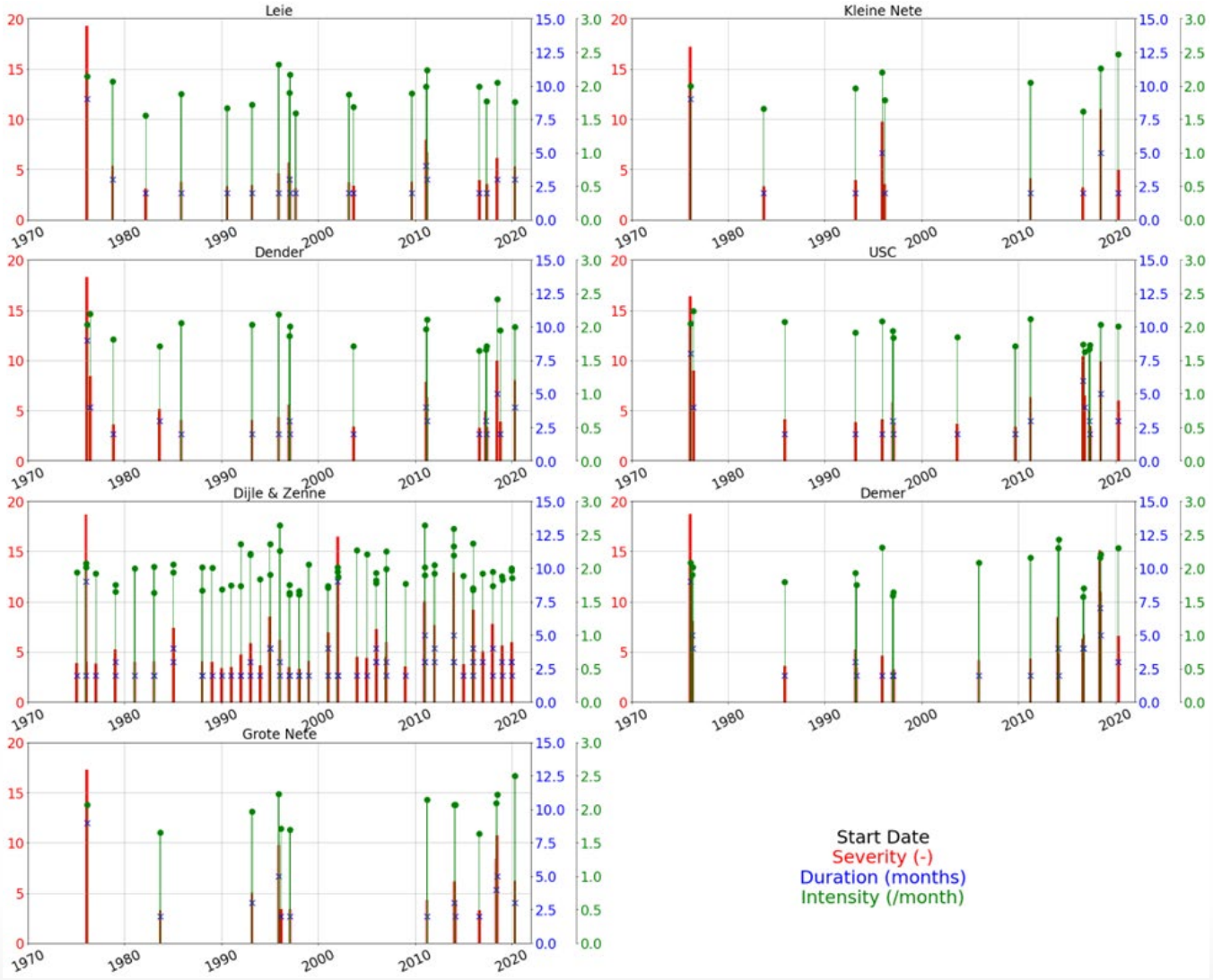
Source: Interreg North Sea Region IMMERSE

- Catchment area: 21.863 km²
- River length: 360 km
- Transboundary: Belgium (61%), France (31%), The Netherlands (8%)
- Highly urbanized
- Scheldt Estuarium: influence of the tides

DROUGHTS



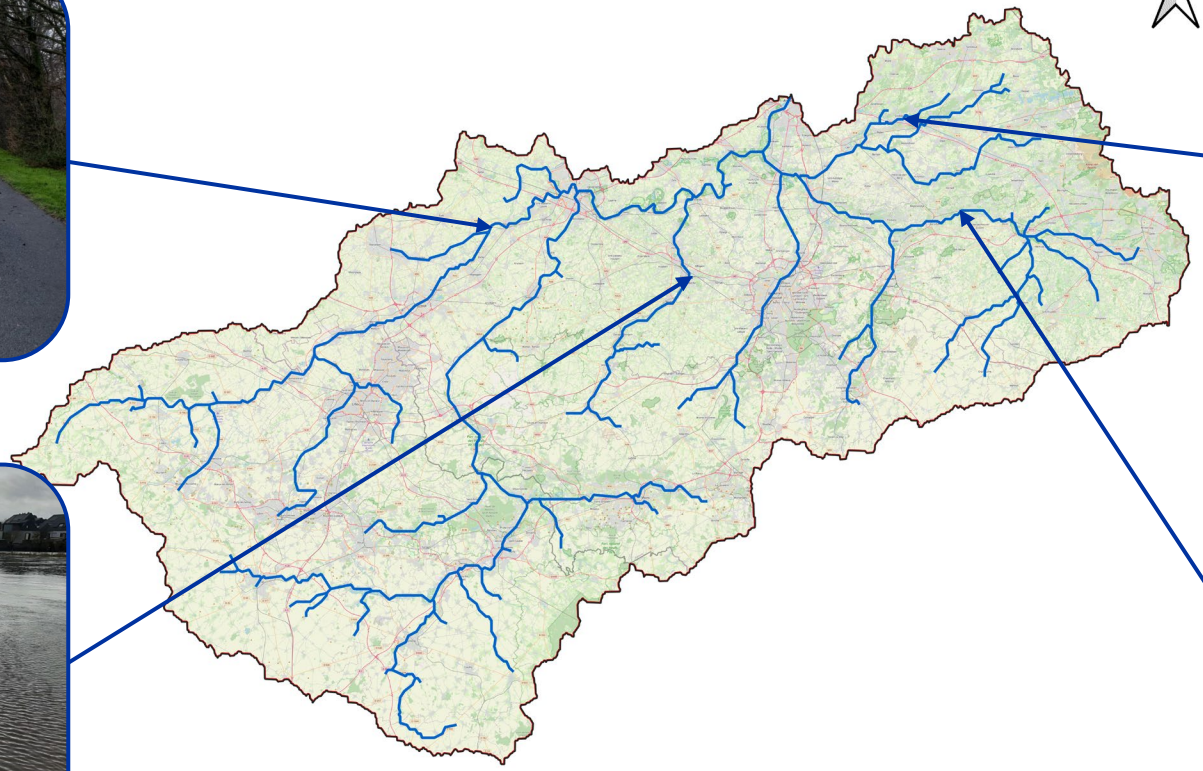
Source: Geopunt Vlaanderen



Source: Yimer, 2024

FLOODS (JANUARY 2024)

Leie



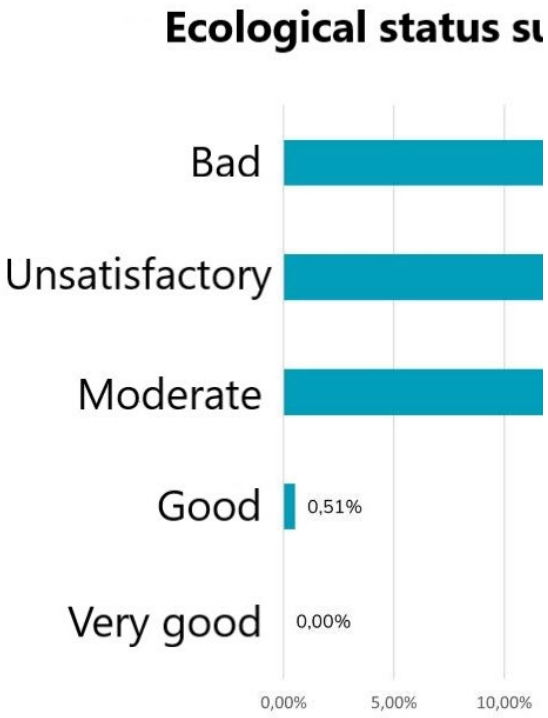
Kleine Nete

Dender

Demer

Source photos: Hydrologisch Informatie Centrum & De Vlaamse Waterweg nv, 2024

WATER QUALI



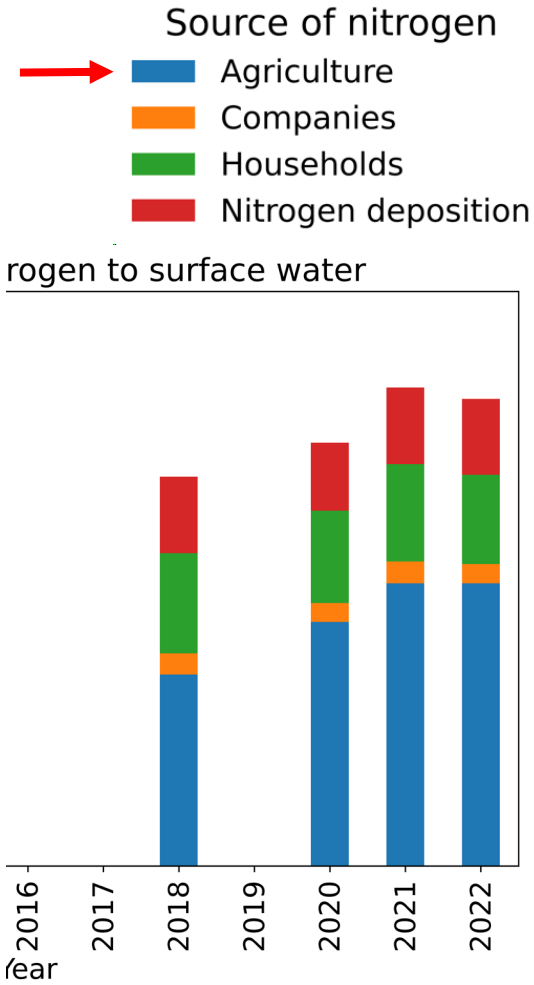
Source: Flemish Envi

ton Koene

Water quality in Flanders is deteriorating instead of improving: fertilization remains a problem

The water quality in Flanders deteriorated last winter instead of improving. The standard for nitrate was exceeded in a quarter of the watercourses examined. And the amount of nitrate in the groundwater has also risen again, to the highest level since 2010. The main culprit remains the fertilization of Flemish fields.

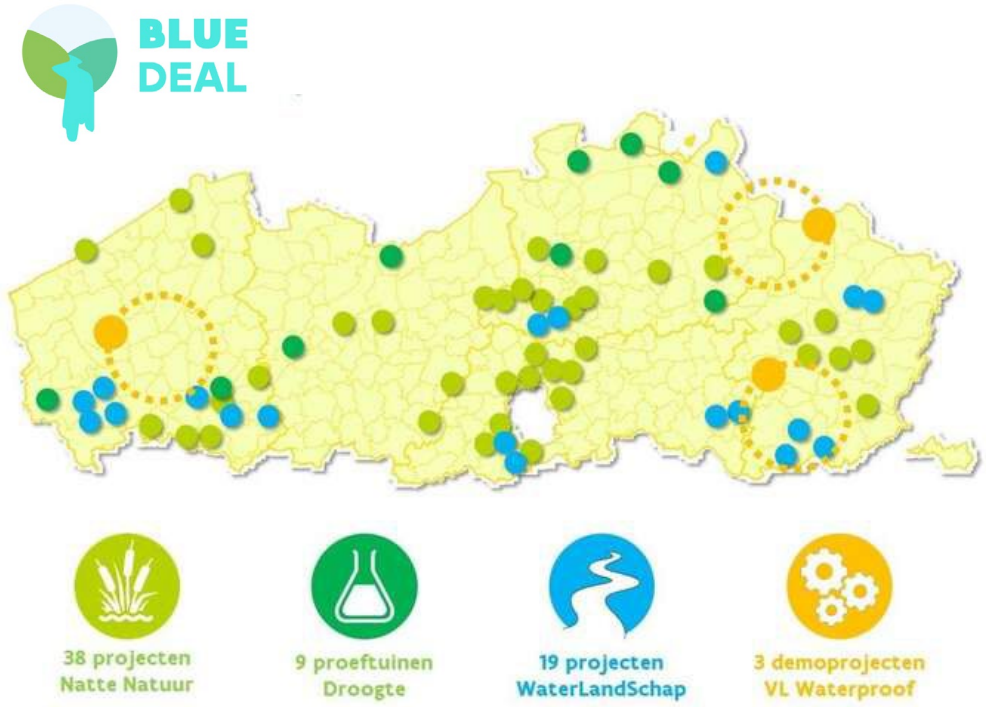
Source: vrt news (21 February 2024), journalist: Denny Baert



ironmental Agency, 2023

CURRENT NATURE-BASED SOLUTIONS

Blue Deal



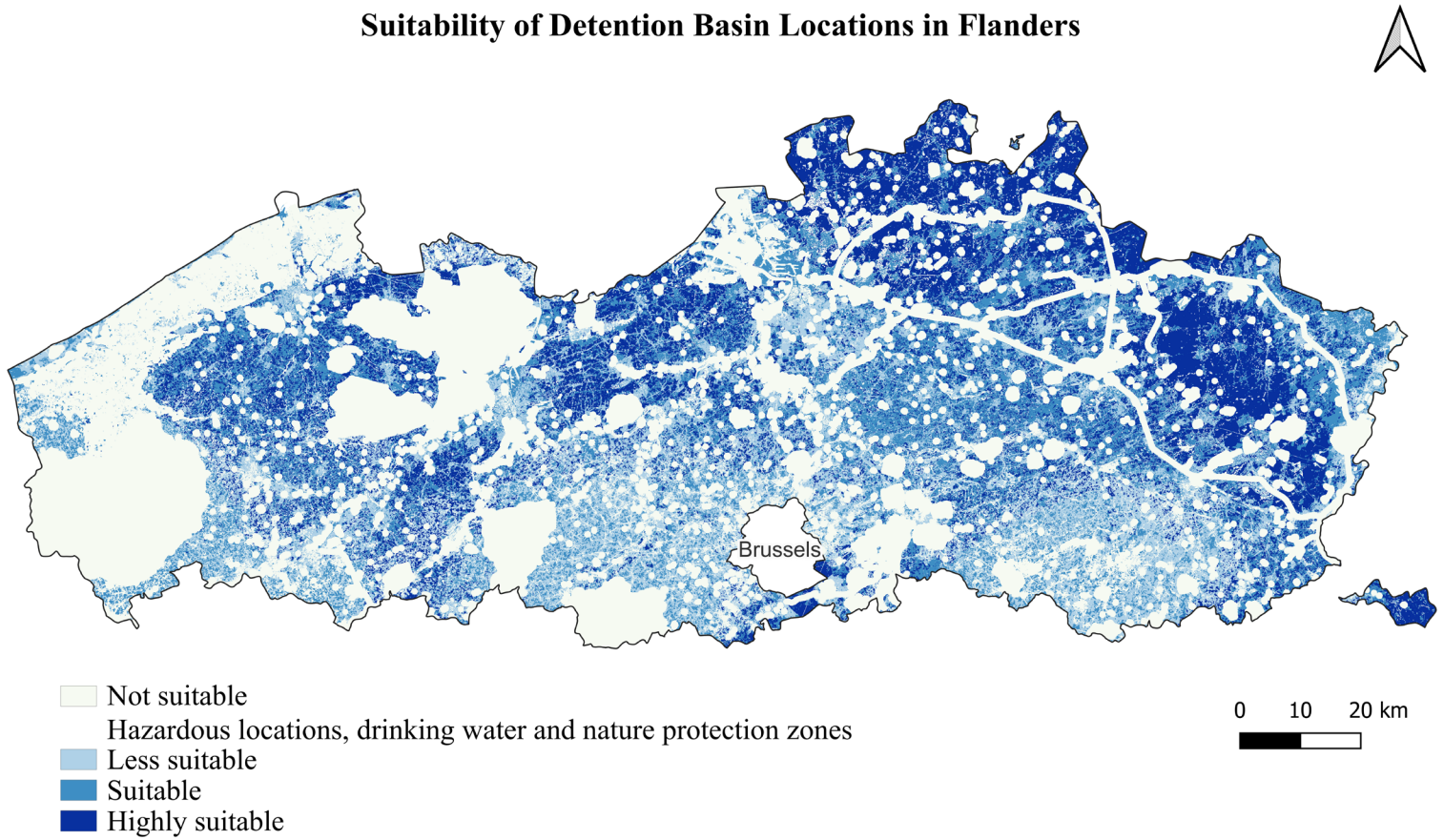
Source: Nationaal Park Scheldevallei

Sigmaplan

Source: Sigmaplan (Flanders Government)

HIGH POTENTIAL OF NATURE-BASED SOLUTIONS

Access to article



+/- 2500 km²
Highly suitable locations!

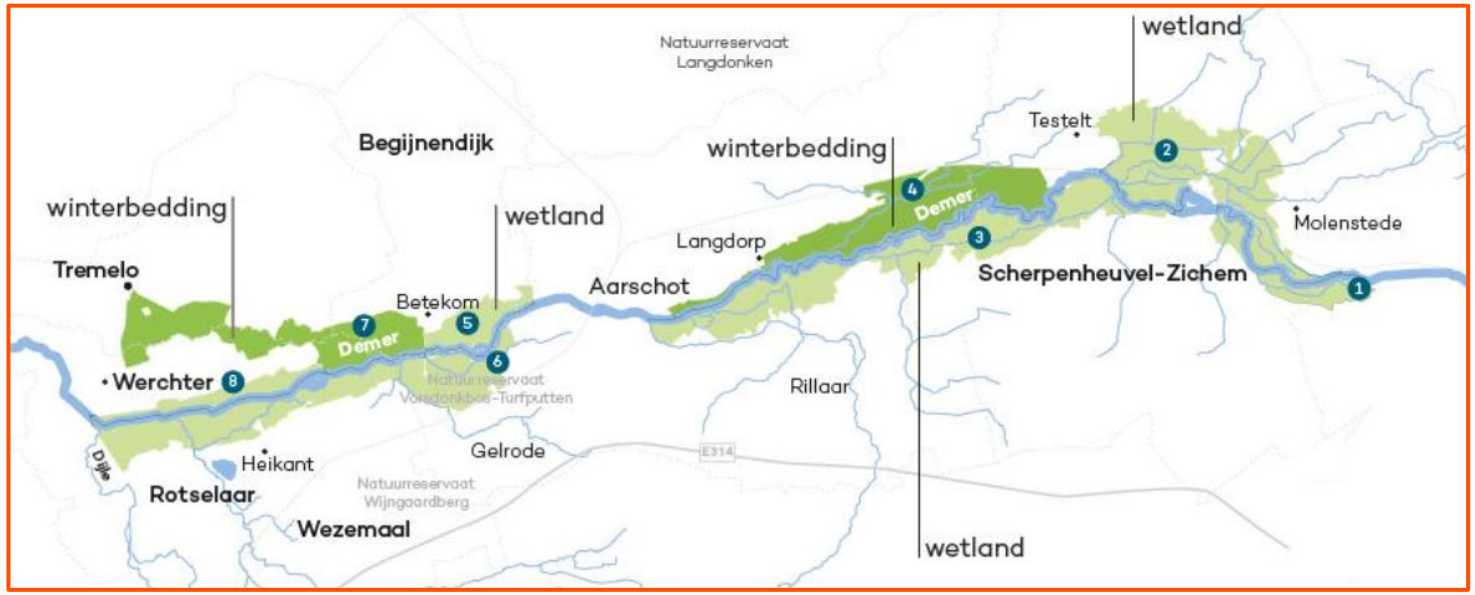
Source: De Trift & Yimer, 2024 (Journal of Water Research)

Can SWAT+ be used in representing these wetlands?

DEMER SUBBASIN: CASE STUDY

Demer Basin
2.334 km²

Wetlands (Sigmaplan)
28,51 km²

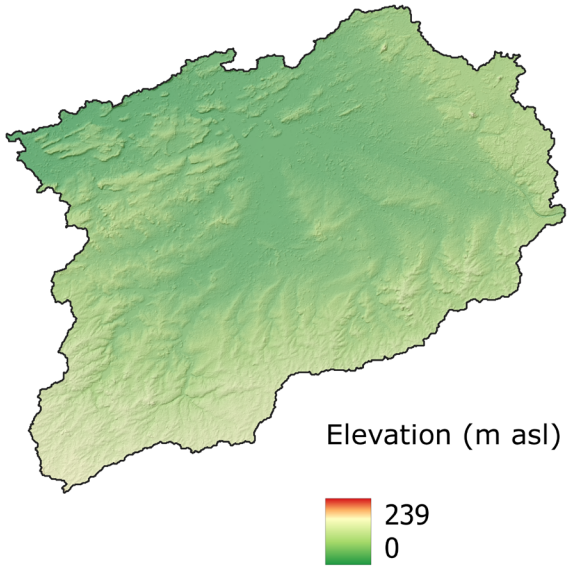


Source: Sigmaplan (Flanders Government)

Source: Interreg North Sea Region IMMERSE

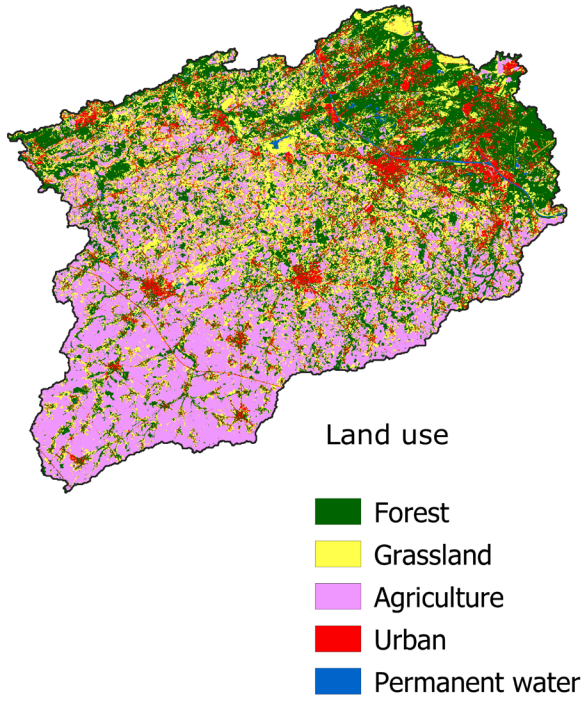
MODEL SETUP: INPUT

Elevation



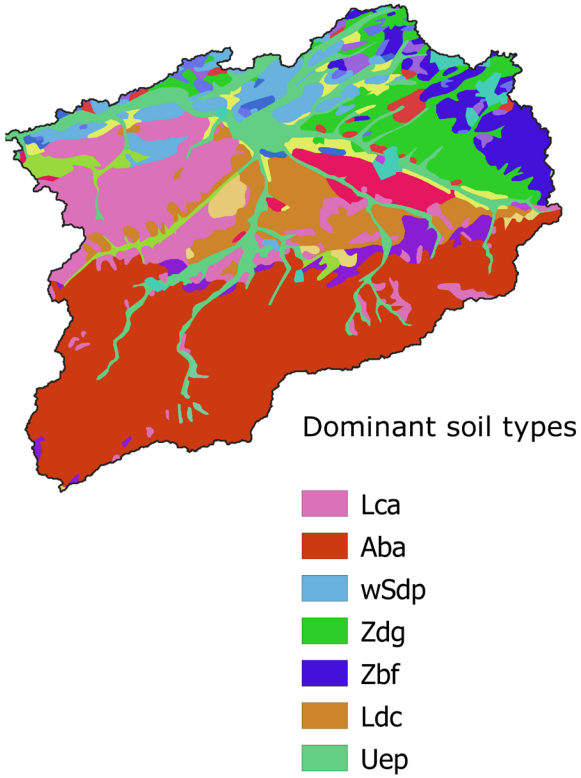
SRTM (30m)

Land Use



ESA (10m)

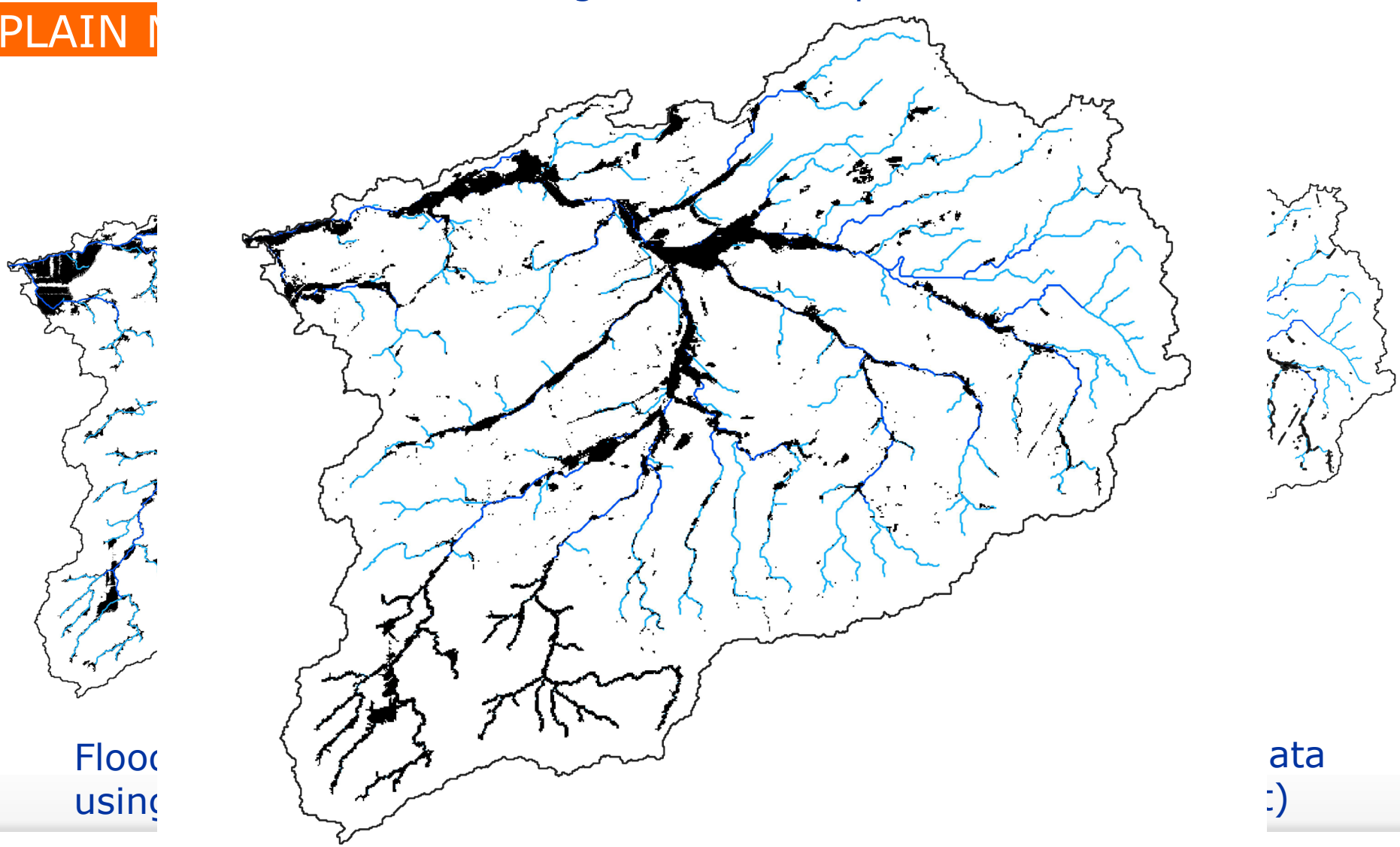
Soil



Dondeyne and Legrain, 2017 (30m)

Merge two floodmaps

FLOODPLAIN M

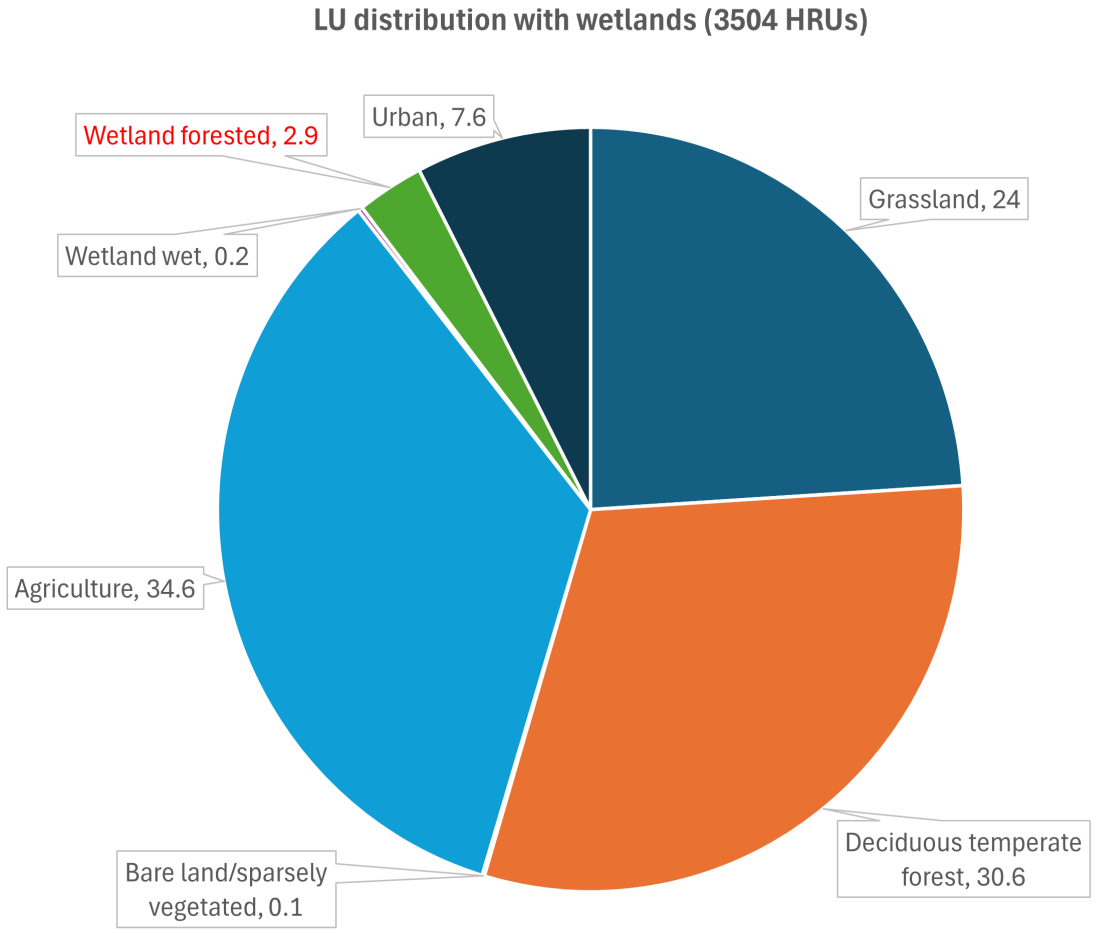


Flooc
using

ata
:)

HYDROLOGICAL RESPONSE UNITS

- HRUs: 11071 → Simplify
- Sub-basins: 21
- Channels: 183
- Aquifer: 43

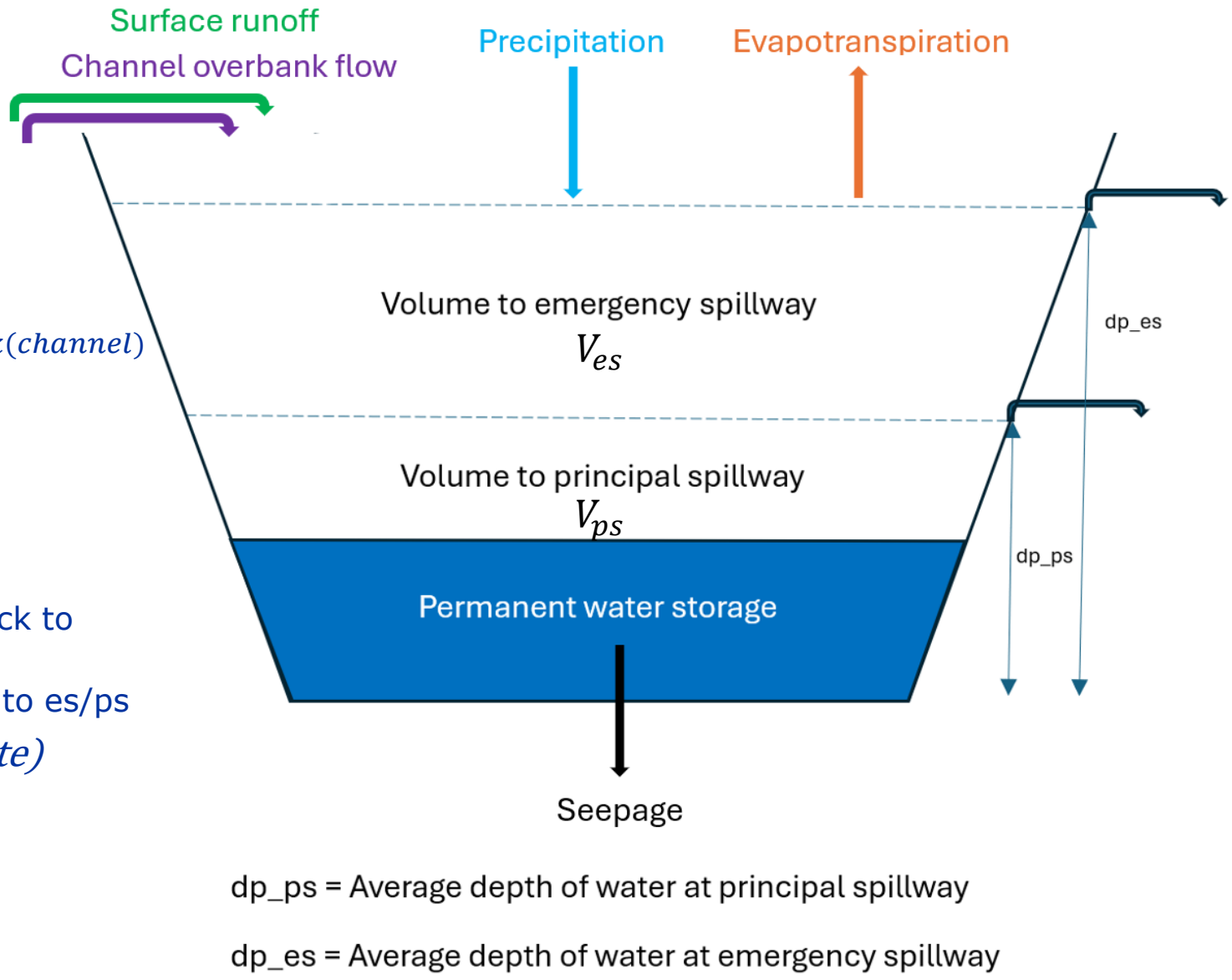


WETLANDS IN SWAT+

- Volume stored in wetland:
  - $V_{wetland} = V_{in} - V_{out} - V_{flood} + V_{overbank(channel)}$
- Water release volume:
  - $V_{release} = = V_{actual} - V_{ps\ or\ es}$
- Set $V_{release}$ back to channel by:
  - Using lag (number of days it takes to flow back to channel)
  - Calculation threshold value based on volume to es/ps

$$Threshold\ b_{lo} = V_{ps\ or\ es} * C\ (release\ cte)$$

$$V_{release} = \frac{V_{in} - b_{lo}}{C}$$



dp_ps = Average depth of water at principal spillway

dp_es = Average depth of water at emergency spillway

WETLANDS IN SWAT+: FILES

- Wetland implementation → wetland.wet
- Wetland parameters → hydrology.wet
  - dp_ps = 0.5 m
  - dp_es = 1.5 m
  - k (default)
  - Evap (default)
- Wetland release decision table → res_rel.dtl
- Linkage between channels and floodplains → chan-surf.link

hydrology.wet: written by SWAT+ editor v2.3.3 on 2024-06-05 20:43 for SWAT+ rev.60.5.7

name	hru_ps	dp_ps	hru_es	dp_es	k	evap
hydwet0209	0.10000	20.00000	0.25000	100.00000	0.01000	0.70000
hydwet0272	0.10000	20.00000	0.25000	100.00000	0.01000	0.70000
hydwet0273	0.10000	20.00000	0.25000	100.00000	0.01000	0.70000
hydwet0369	0.10000	20.00000	0.25000	100.00000	0.01000	0.70000
hydwet0381	0.10000	20.00000	0.25000	100.00000	0.01000	0.70000

name	conds	alts	acts							
wetland	2	2	2							
var	obj	obj_num	lim_var	lim_op	lim_const	alt1	alt2			
vol_wet	hru	0	pvol	*	1.00000	>	-			
vol_wet	hru	0	evol	*	1.00000	<	>			
act_typ	obj	obj_num	name	option	const	const2		fp	outcome	
release	hru	0	below_emer	days	10.00000	0.00000		null	y	n
release	hru	0	above_emer	days	2.00000	0.00000		null	n	y

chan-surf.lin: Channel Floodplain Linkage

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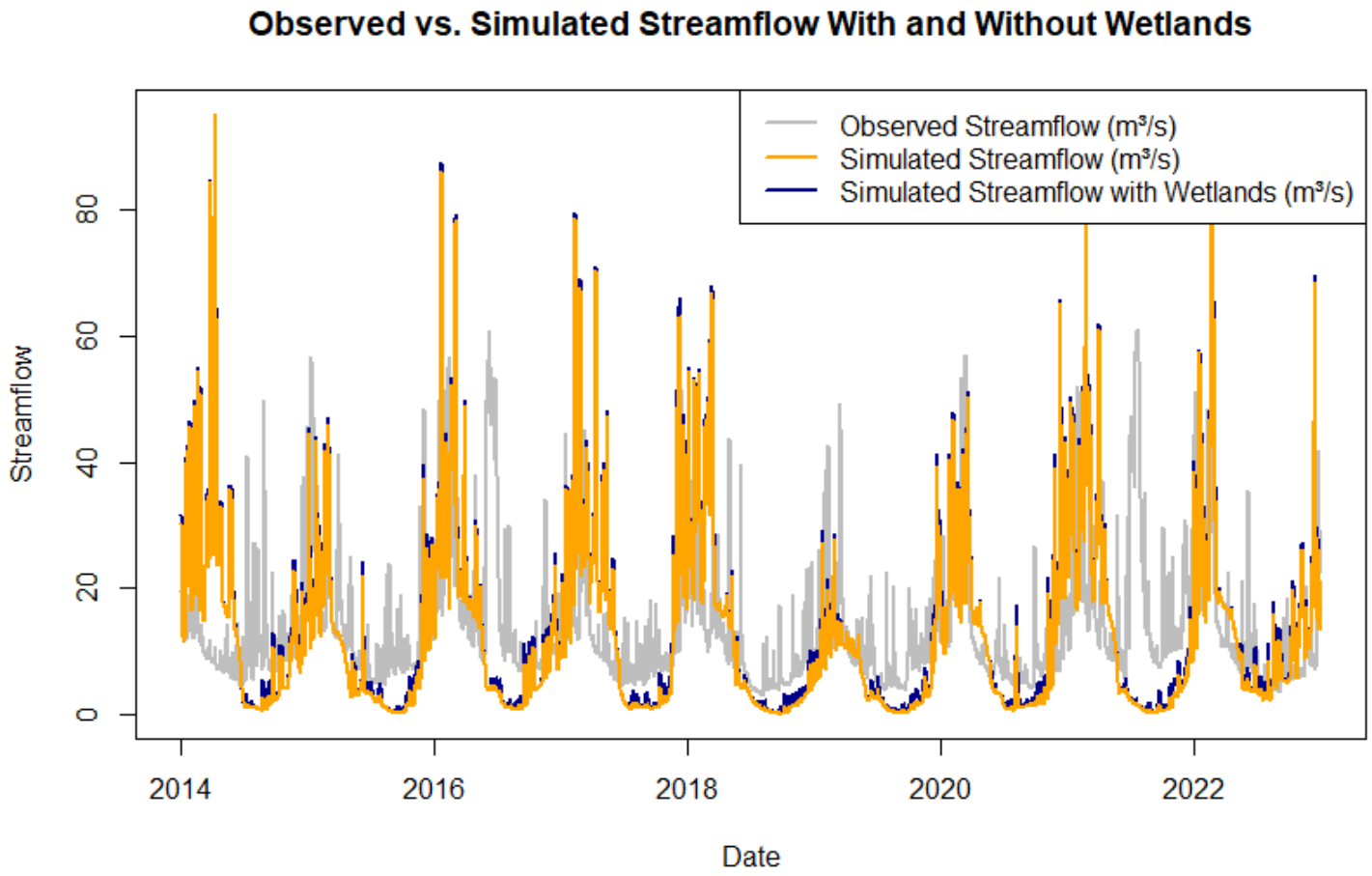
NUMB	NAME	NSPU	OBTYP	OBTYP_NO
1	cha001	1	ru	1
2	cha002	1	ru	3
3	cha003	1	ru	5
4	cha004	1	ru	7
5	cha005	1	ru	9
6	cha006	1	ru	11
7	cha007	1	ru	13
8	cha008	1	ru	15
9	cha009	1	ru	17
11	cha011	1	ru	21

WETLANDS IN SWAT+: RESULTS



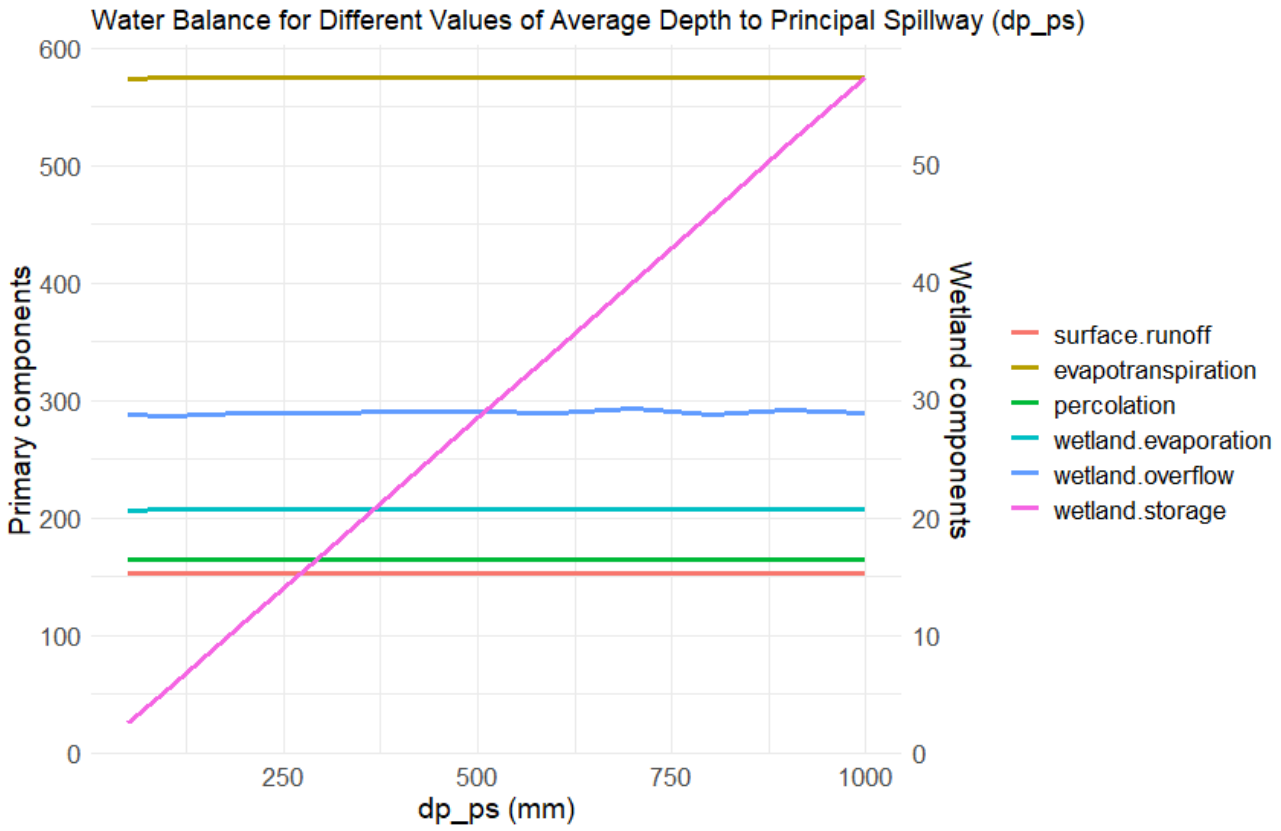
Observed and simulated streamflow at the main station in Aarschot (downstream Demer)

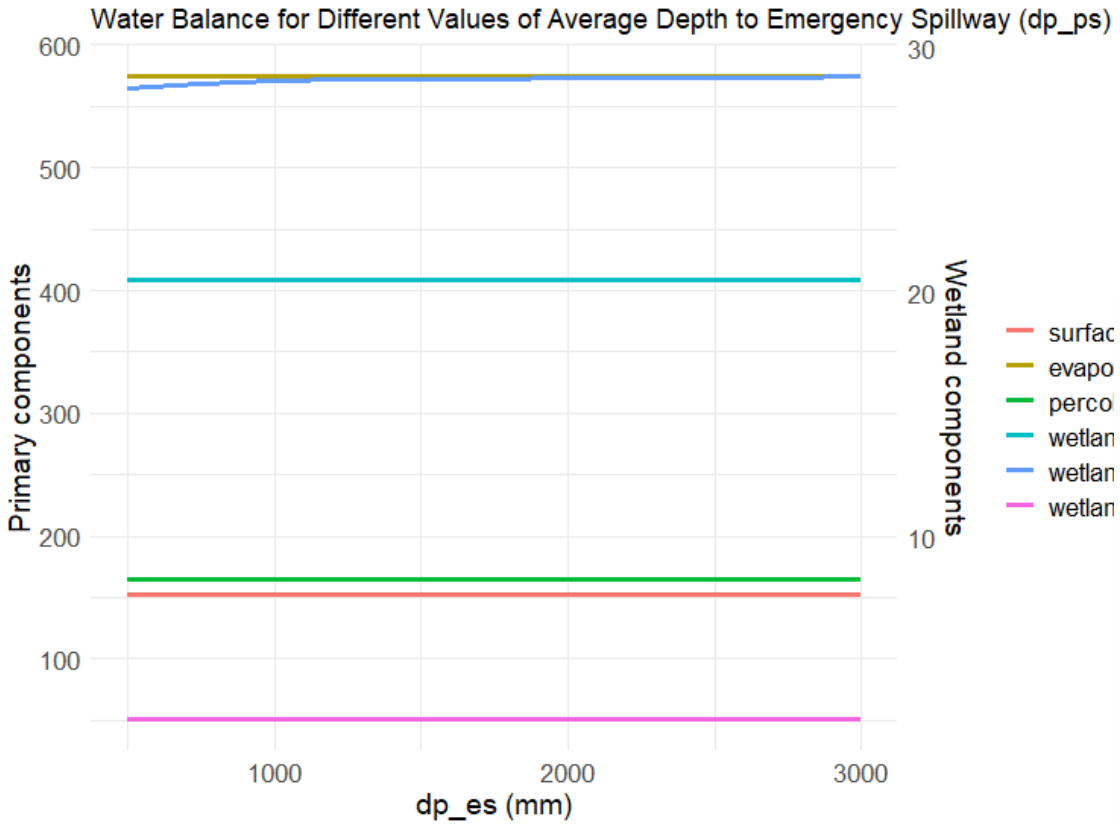
WORK IN PROGRESS

Water balance components (mm)	No wetlands	Wetlands
Precipitation	852	852
Surface runoff	121	141
Evapotranspiration	562	577
Percolation	176	163
Lateral flow to channel	0.047	0.045
Wetland evaporation	0.899	20.4
Wetland overflow	1.41	29
Wetland storage	0.056	2.590

Annual average water balance (mm) with and without implementation of wetlands in the Demer Basin

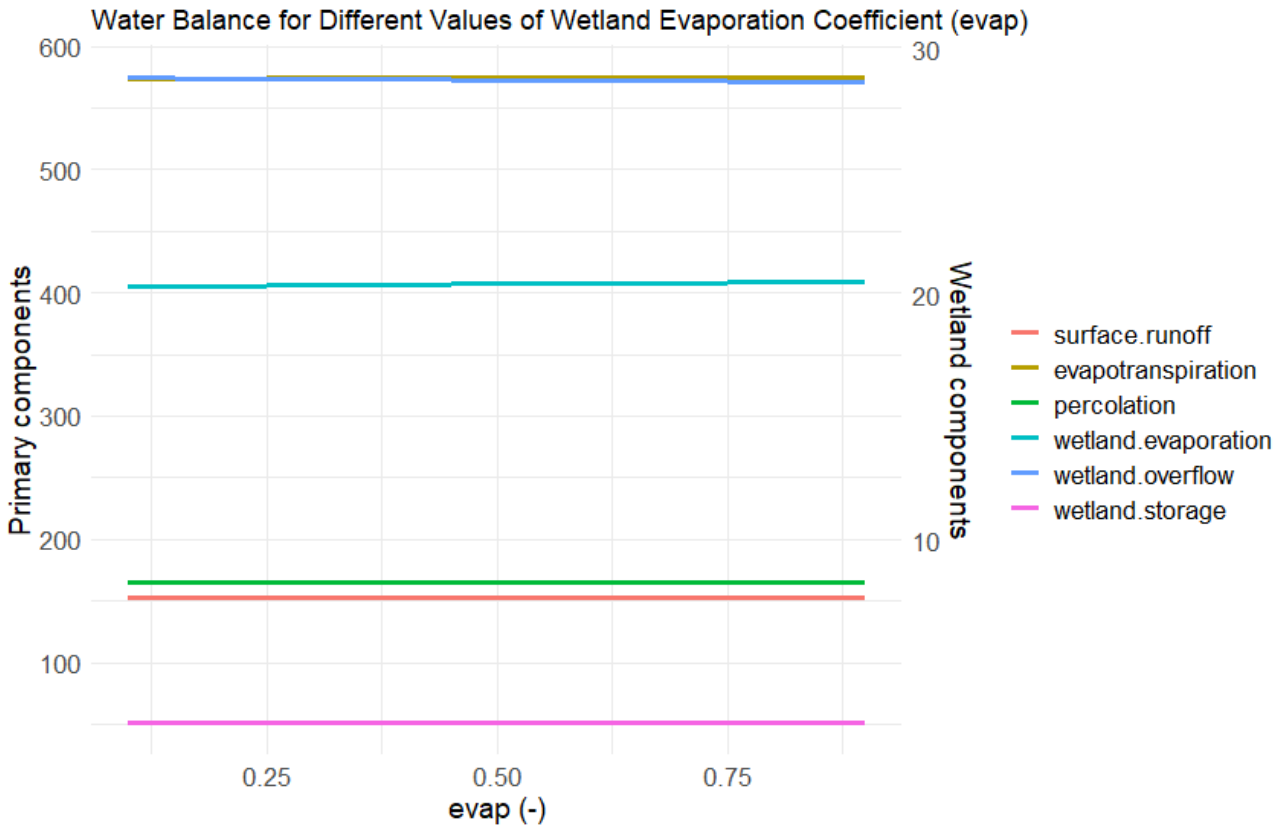
WETLANDS IN SWAT+: RESULTS



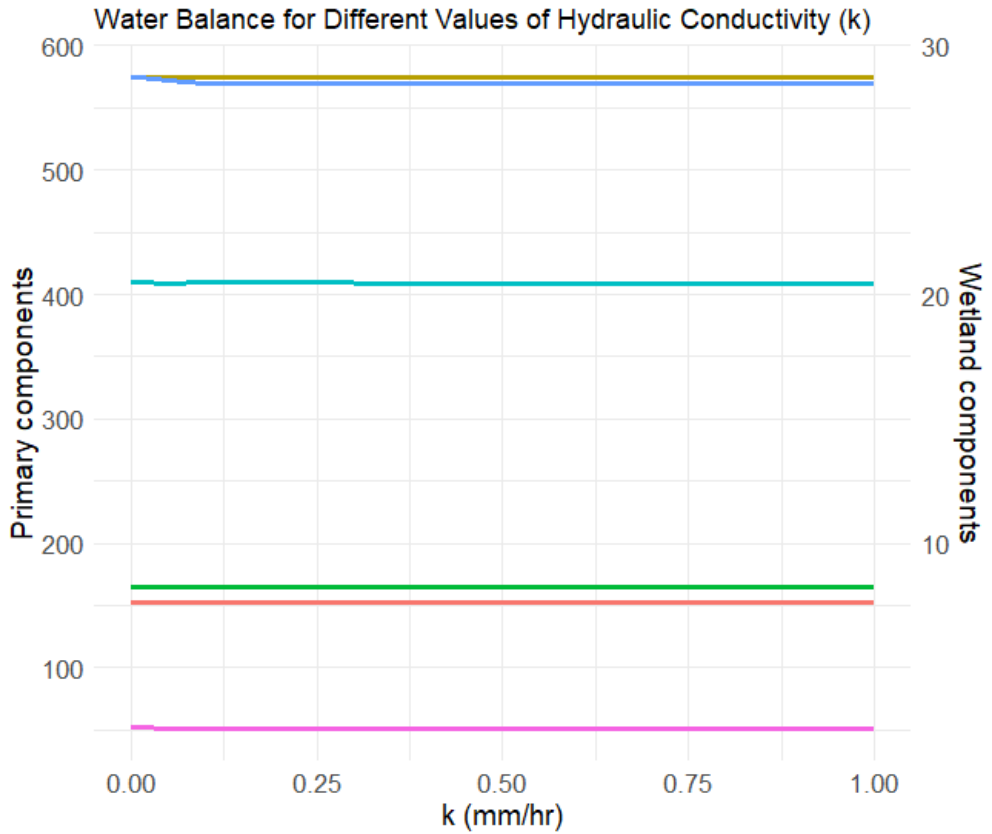


In general: increase **dp_es & dp_ps** → small **increase** surface runoff, wetland overflow, and wetland storage

WETLANDS IN SWAT+: RESULTS



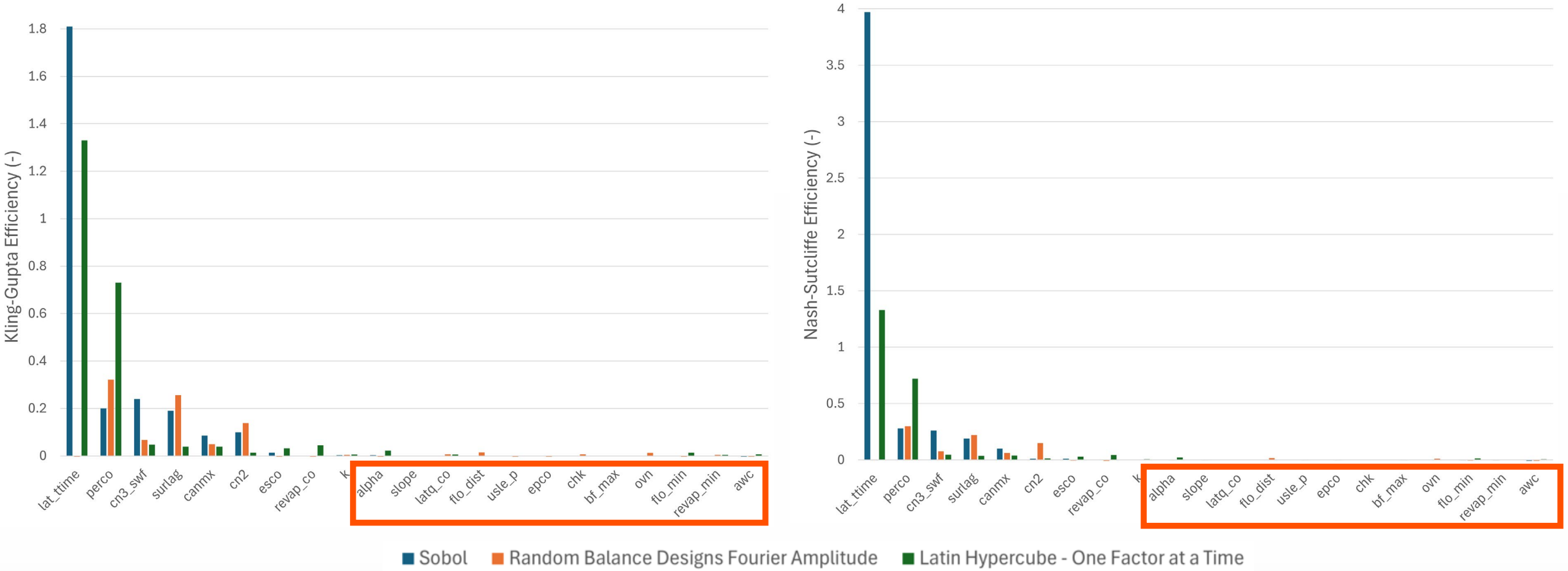
Increase **evap** → small **decrease** surface runoff, wetland overflow and storage
→ small **increase** ET and wetland evaporation



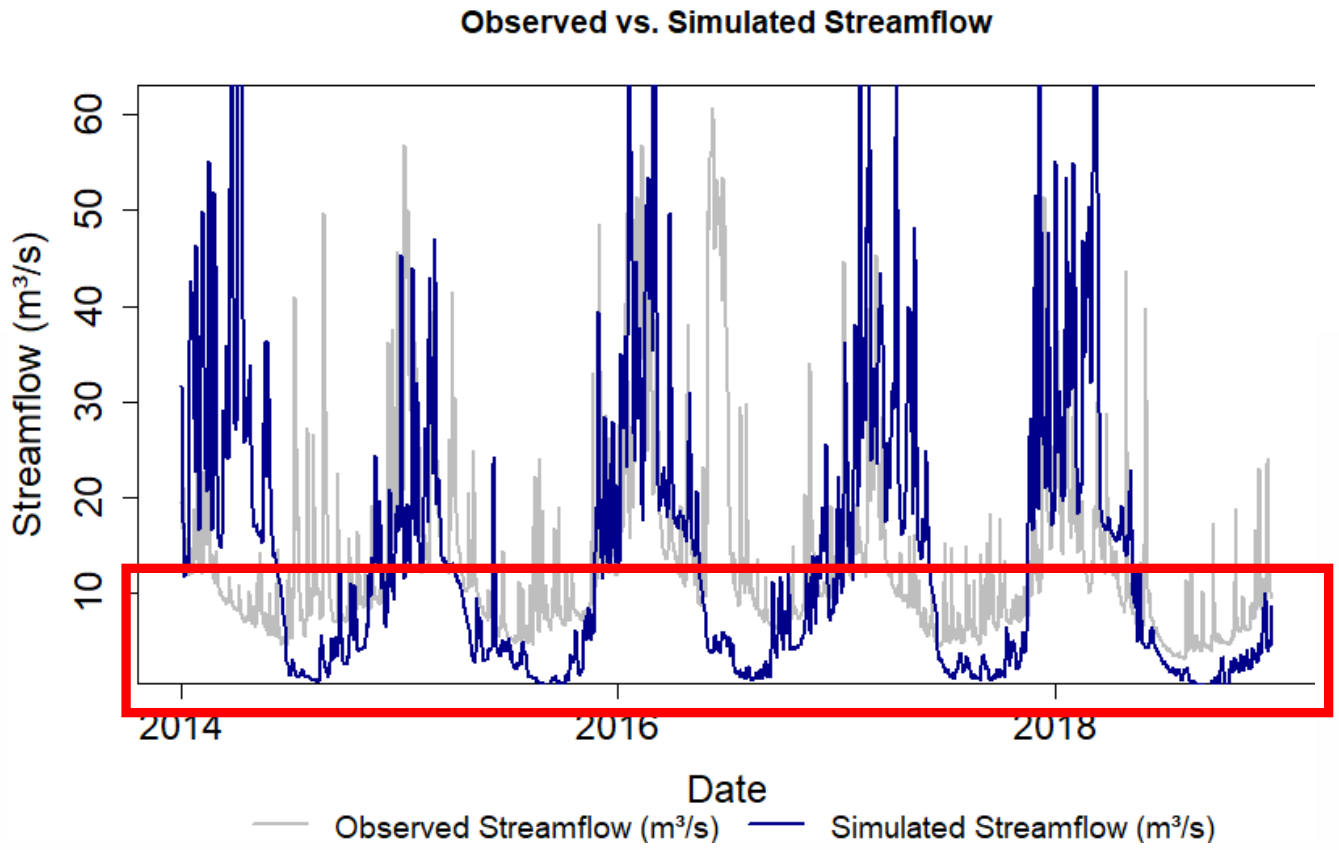
Increase **k** → small **decrease** surface runoff, ET, wetland evaporation, overflow and storage
→ small **increase** percolation

SENSITIVITY ANALYSIS

Low sensitivity!



CALIBRATION IN SWAT+ TOOLBOX USING STREAMFLOW OBSERVATIONS



NSE	KGE	PBIAS	RMSE
0.026	0.278	7.210	10.012

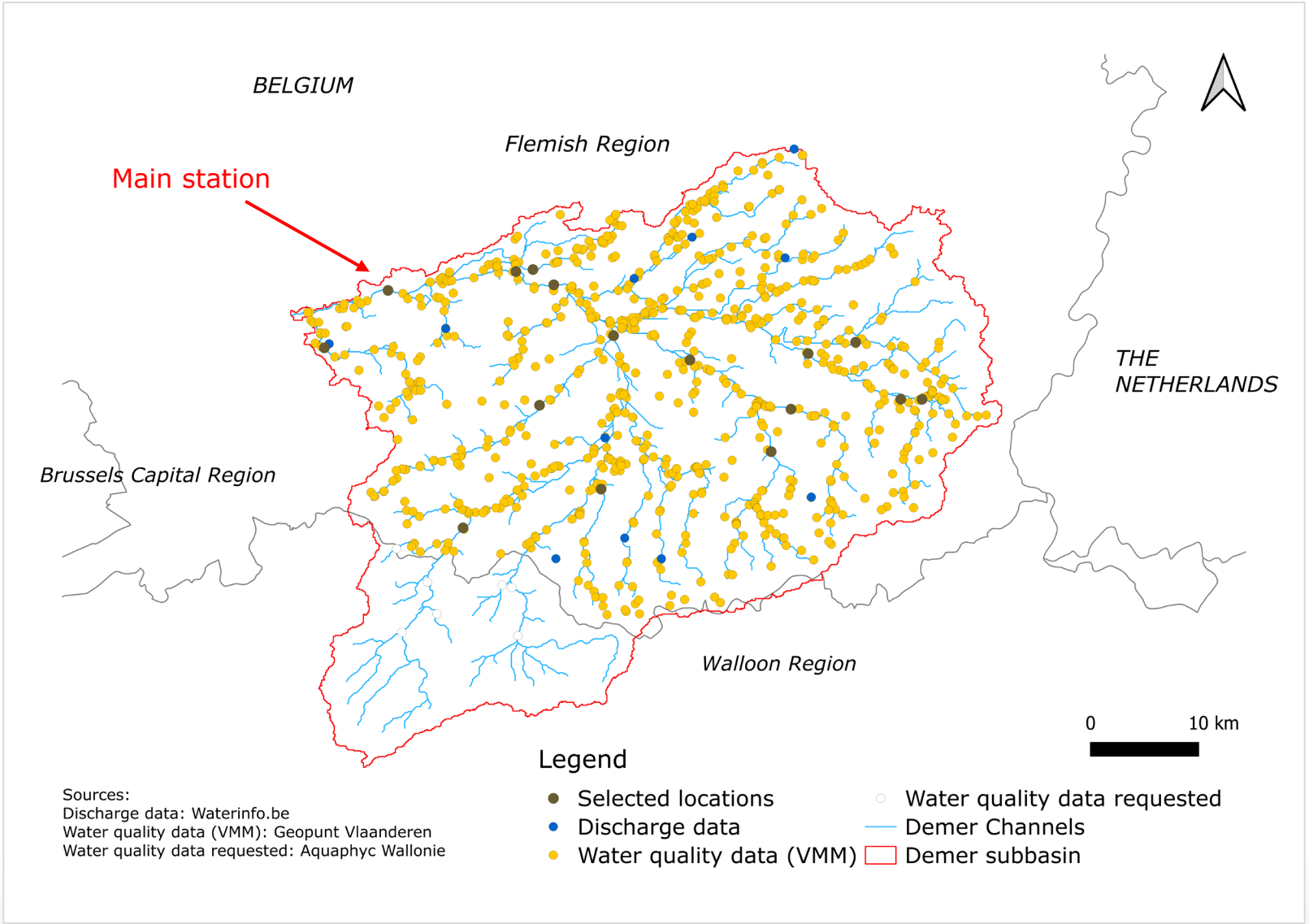
- Calibration period: 2012-2018
- Dynamically Dimensioned Search (DDS) algorithm

WORK IN PROGRESS

- Non-representation of baseflow -> coupling with gwflow module!

WATER QUALITY DATA

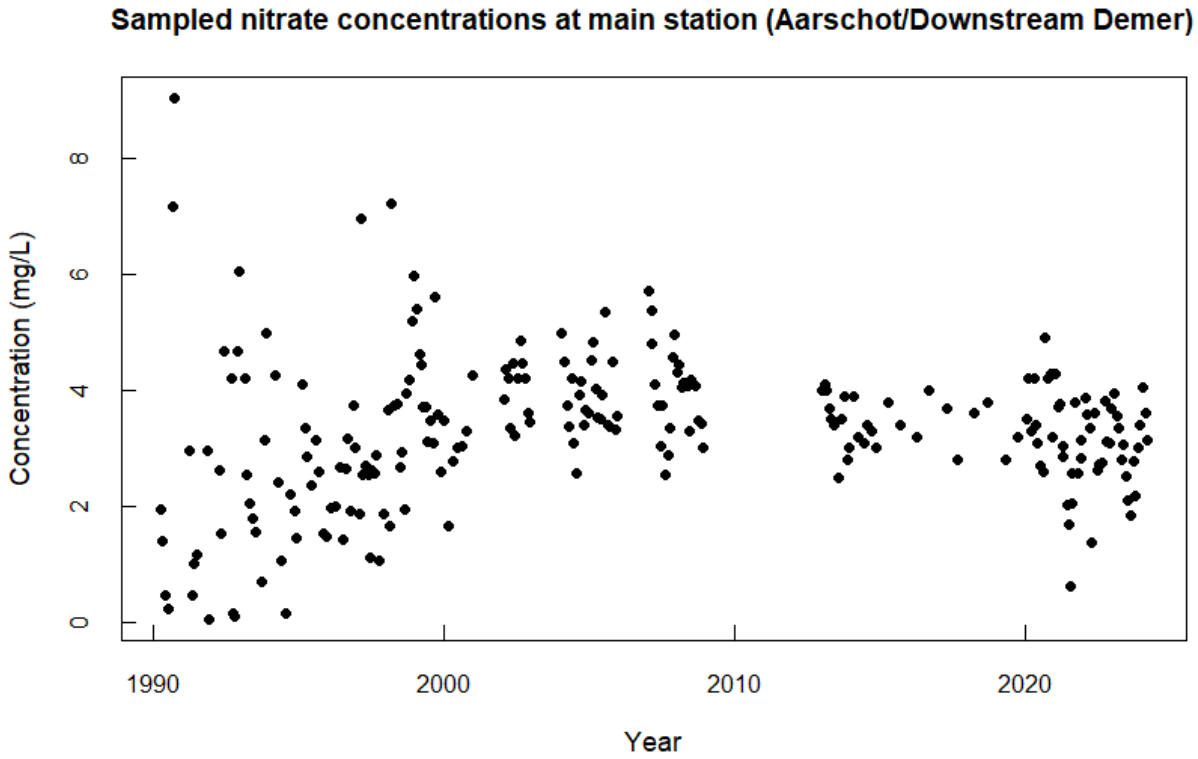
- Selection of data for calibration
- 16 discharge stations with matching data for different water quality parameters (NO_3^- NO_2^- NH_3 PO_4^{3-} total N total P …)
- Problem: low temporal coverage of data…



ESTIMATION OF NITRATE CONCENTRATIONS USING WRTDS

WEIGHTED REGRESSION ON TIME, DISCHARGE, AND SEASON

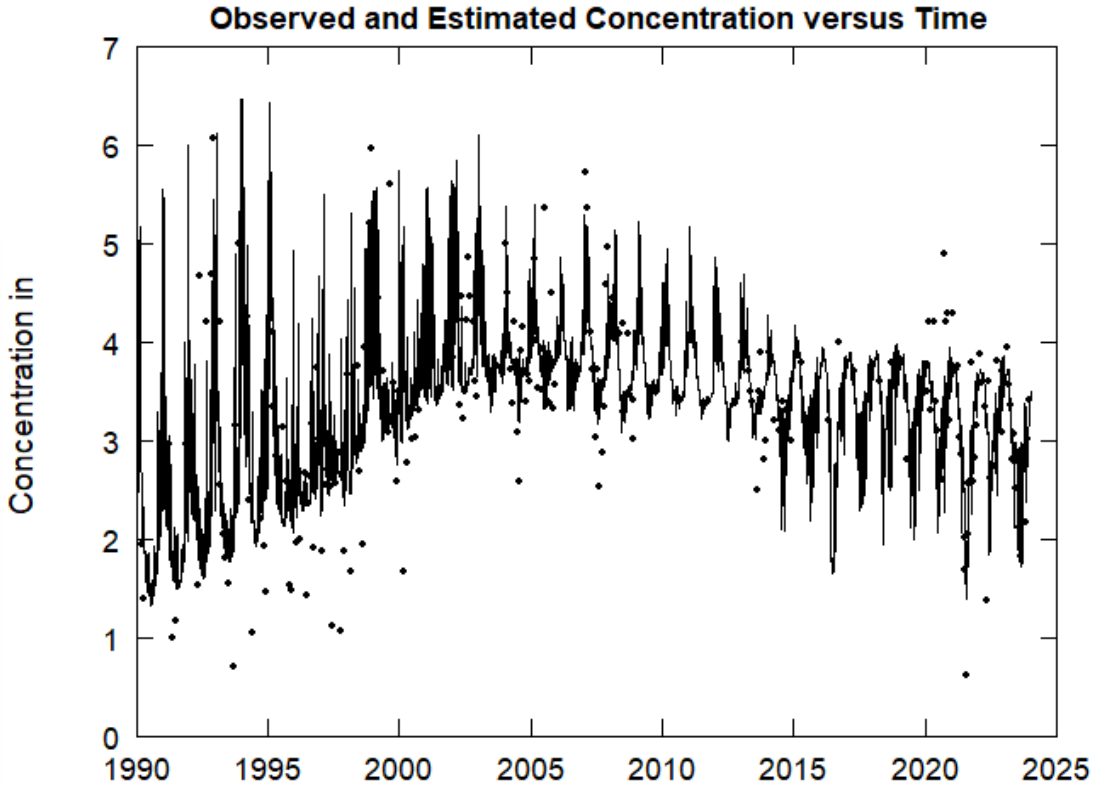
- Weighted regression model accounting for time, discharge, and seasonality
- Choice of model → good performance when (Hirsch et al., 2015) :
  - > 100 discrete data samples
  - > 10 years coverage
  - Daily streamflow + not flashy!
- Methodology explained in detail by Hirsch et al. (2010)



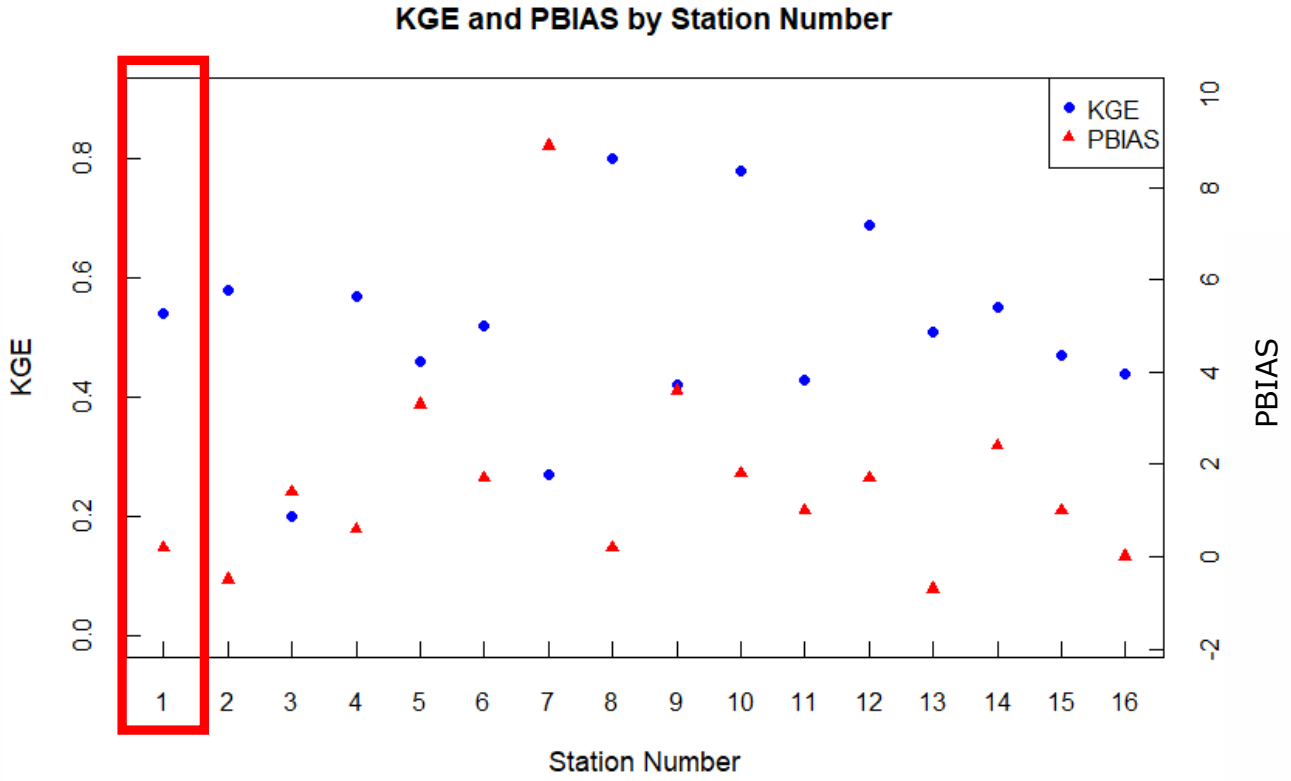
Hirsch, Robert M., Douglas L. Moyer, and Stacey A. Archfield, 2010. Weighted Regressions on Time, Discharge, and Season (WRTDS), With an Application to Chesapeake Bay River Inputs. Journal of the American Water Resources Association (JAWRA) 46(5):857-880. DOI: 10.1111 /j.1752-1688.2010.00482.x

ESTIMATION OF NITRATE CONCENTRATIONS USING WRTDS

WEIGHTED REGRESSION ON TIME, DISCHARGE, AND SEASON



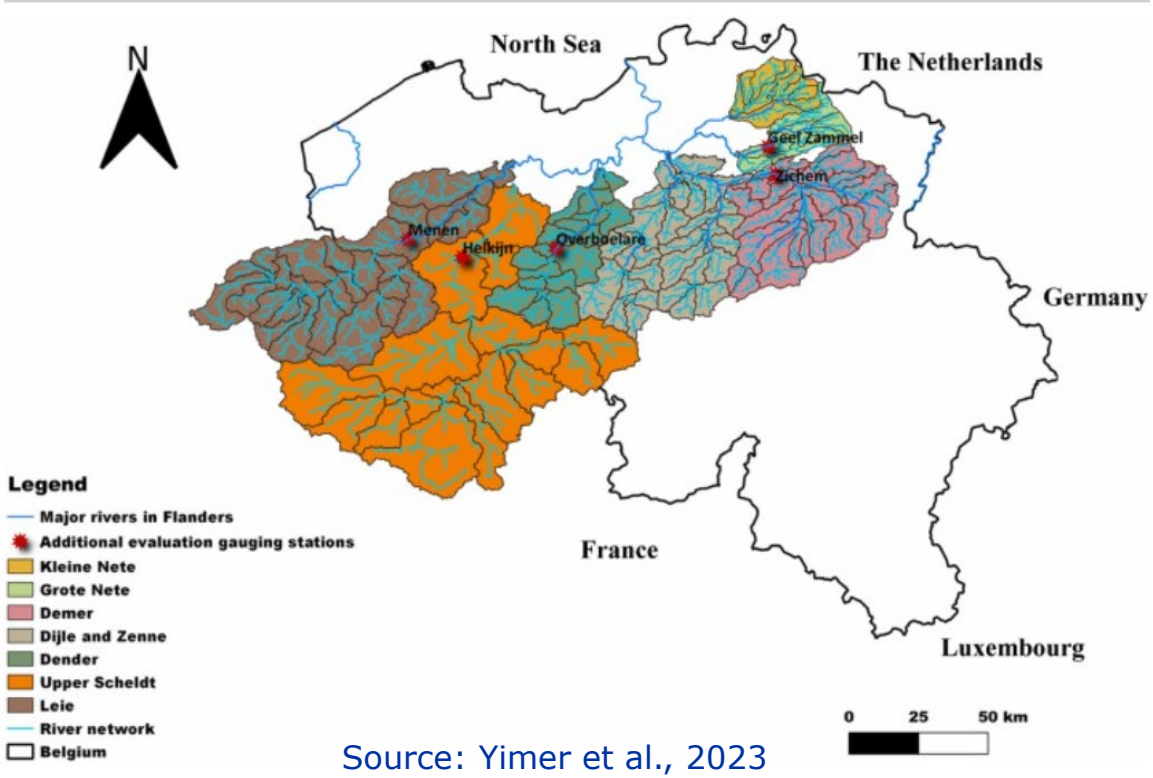
Observed and estimated nitrate concentration at main station in Aarschot (downstream Demer)



Statistical indicators (KGE and PBIAS) per station number

FUTURE RESEARCH

- Couple SWAT+ with groundwater flow module to represent groundwater dynamics

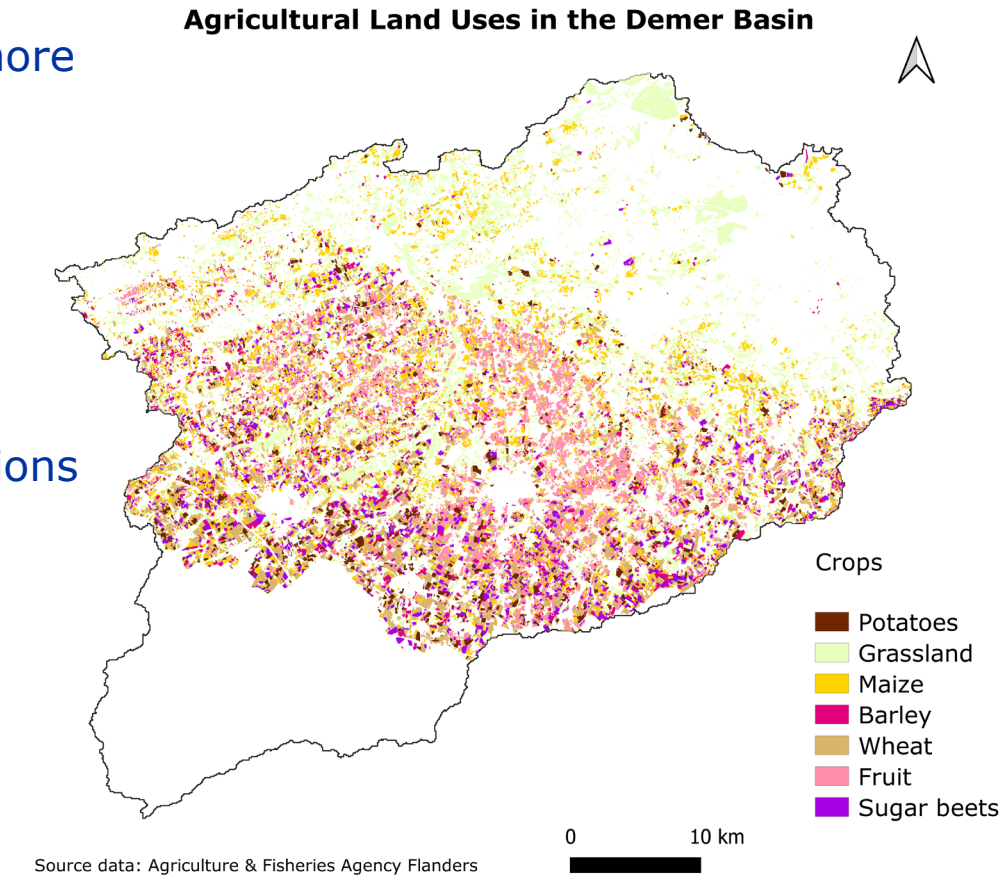


Source: Yimer et al., 2023

Yimer, E. A., T. Bailey, R., Van Schaeybroeck, B., Van De Vyver, H., Villani, L., Nossent, J., & van Griensven, A. (2023). Regional evaluation of groundwater-surface water interactions using a coupled geohydrological model (SWAT+gwflow). *Journal of Hydrology: Regional Studies*, *50*. https://doi.org/10.1016/j.ejrh.2023.101532

FUTURE RESEARCH

- Improve estimations of water quality concentrations using more advanced techniques
- Extend estimation for other water quality parameters (phosphorous, suspended sediment concentrations…)
- Multi-site model calibration using these observed concentrations
- Add management schedules
- Calibration of wetland parameters



Thank you!

WATER AND CLIMATE DEPARTMENT

Questions?

lien.de.trift@vub.be

Or

estifanos.addisu.yimer@vub.be

Poster session tonight @ 16h30 – 18h

22 **Mojtaba Shafiei**

Proposal for SWAT+ NBS (Nature-Based Solutions) community in the context of science-policy-practice nexus