Modelling effects of submerged drains on water management and nutrient leaching in the Krimpenerwaard polder

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Introduction

- Submerged drains are promising tools for lowering peat soil subsidence in The Netherlands
- But some hesitations arose because of three pressing questions:

1. will they increase pumping costs and the demand for (scarce) fresh inlet water?
2. will they increase the risk of flooding during long and heavy showers?
3. will they increase nutrient leaching from the nutrient rich peat soils?

Introduction

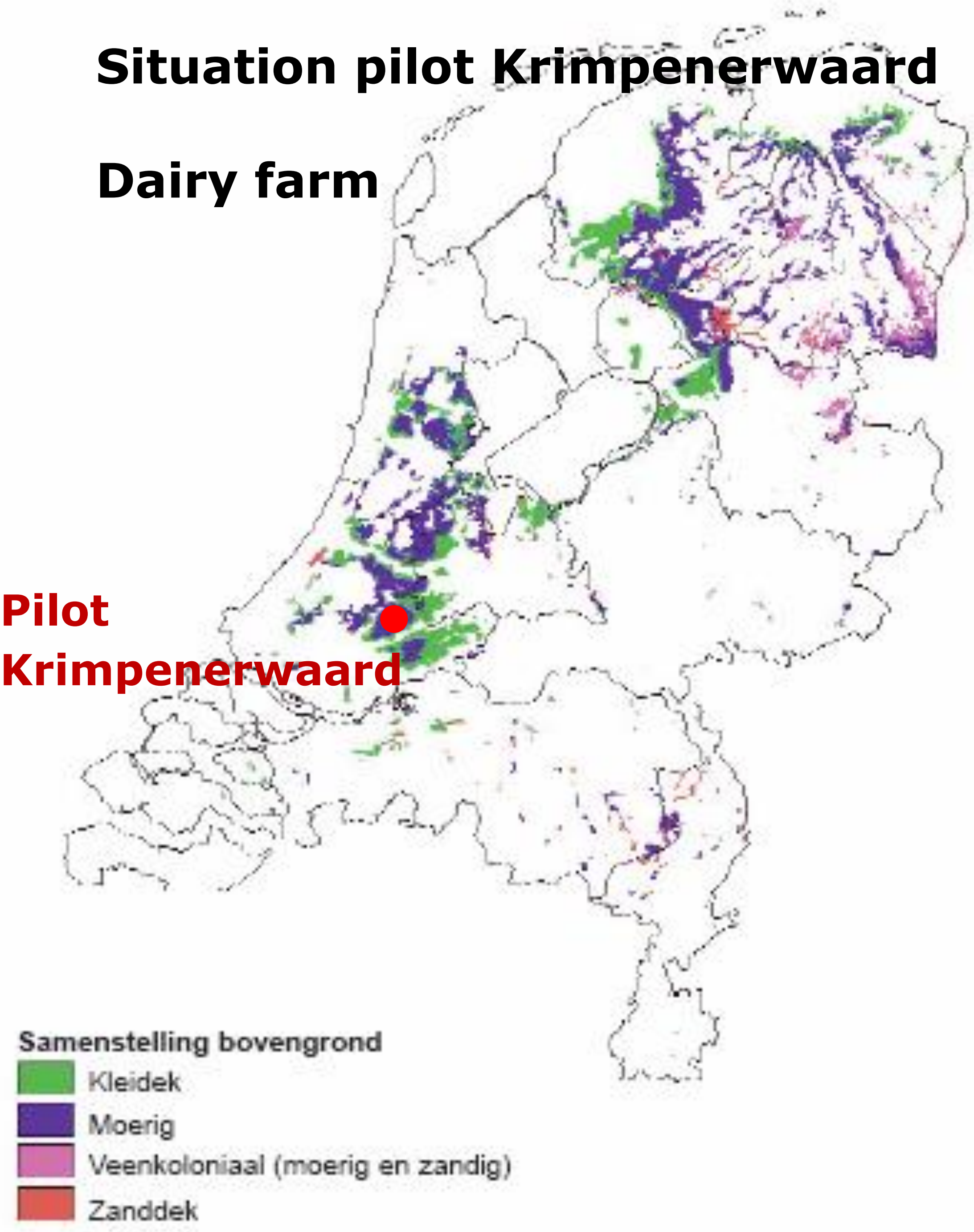
- This model study was conducted to find some answers to these questions

- The modelling was based on results of one of the pilot studies in the peat pasture area of the Netherlands: polder Krimpenerwaard

- Modelling was used to analyse, interpreted and extrapolate the monitoring results

Situation pilot Krimpenerwaard

Dairy farm



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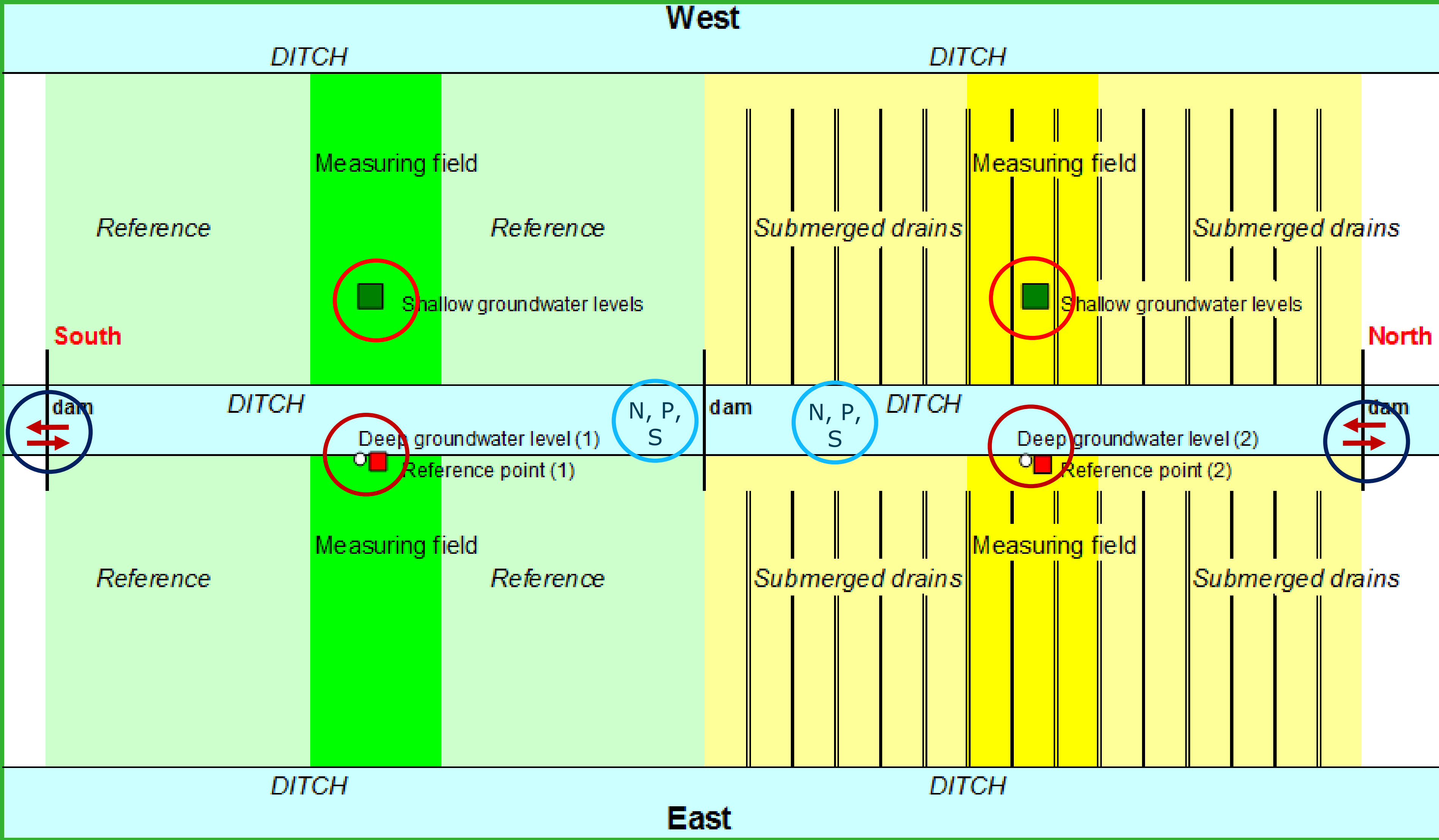
Pilot submerged drains Krimpenerwaard

- Objective:

  monitoring (2 years) effects of submerged drains on:
  - subsidence
  - groundwater level
  - water exchange surface water: drainage & infiltration
  - nutrient loading surface water

- Method:
  - comparing fields without and with drains on one site

Layout fields Krimpenerwaard



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Modelling

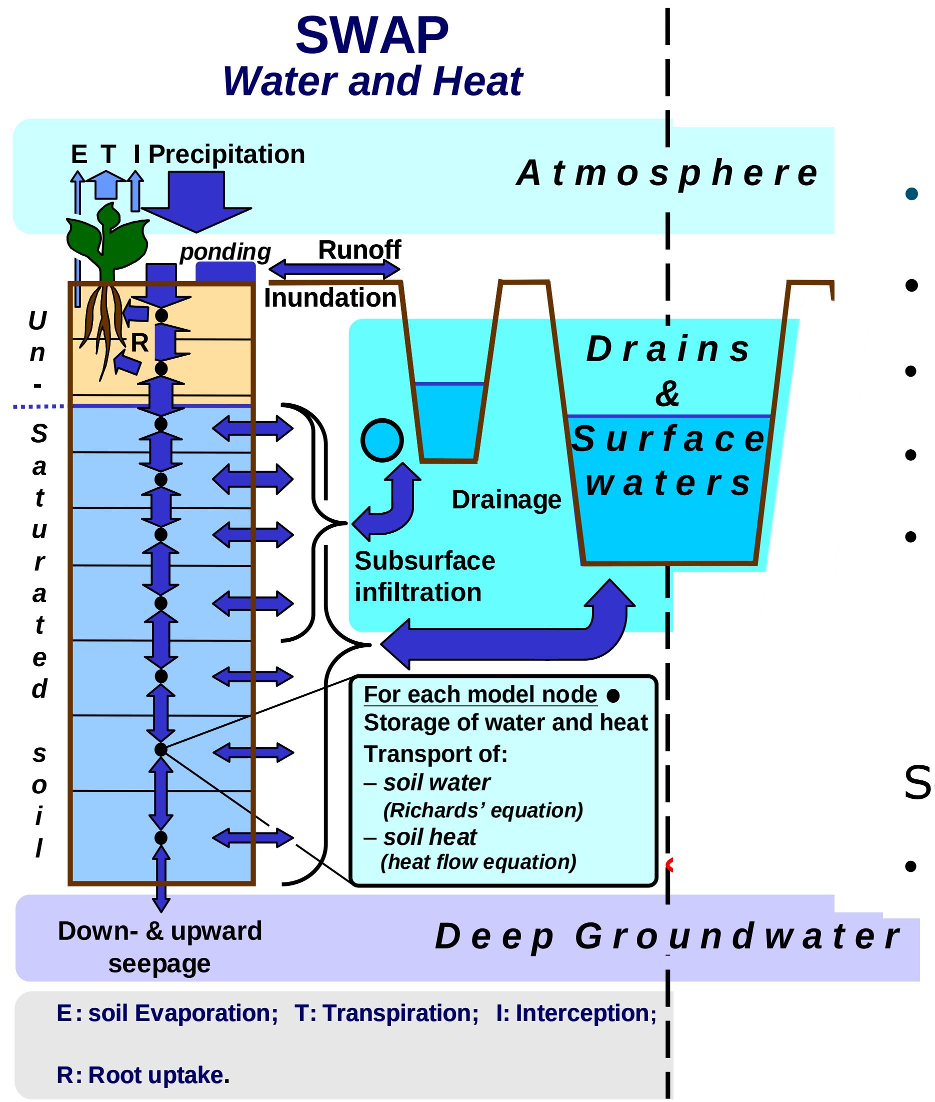
- Objective:
  - Answers to the three questions by:

    analysing, interpreting and extrapolating the

    monitoring results

- Models:
  - SWAP: vadose zone (agro)hydrology
  - ANIMO: carbon and nutrient cycles and nutrient leaching

SWAP model 'Soil Water Atmosphere Plant'



- Hydrology
- Process based
- Dynamic
- One dimensional
- Unsaturated-saturated Richards' equation

Solutes:

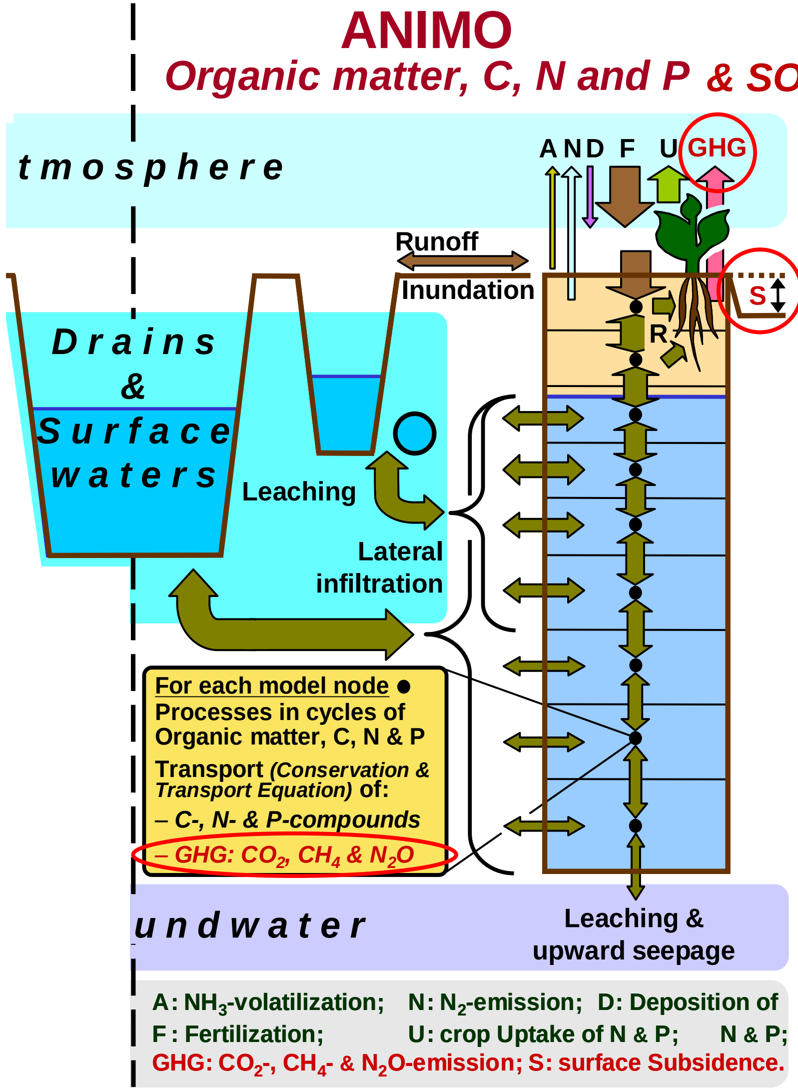
- Pseudo 2D

ANIMO model 'Agricultural NutrIent Model'

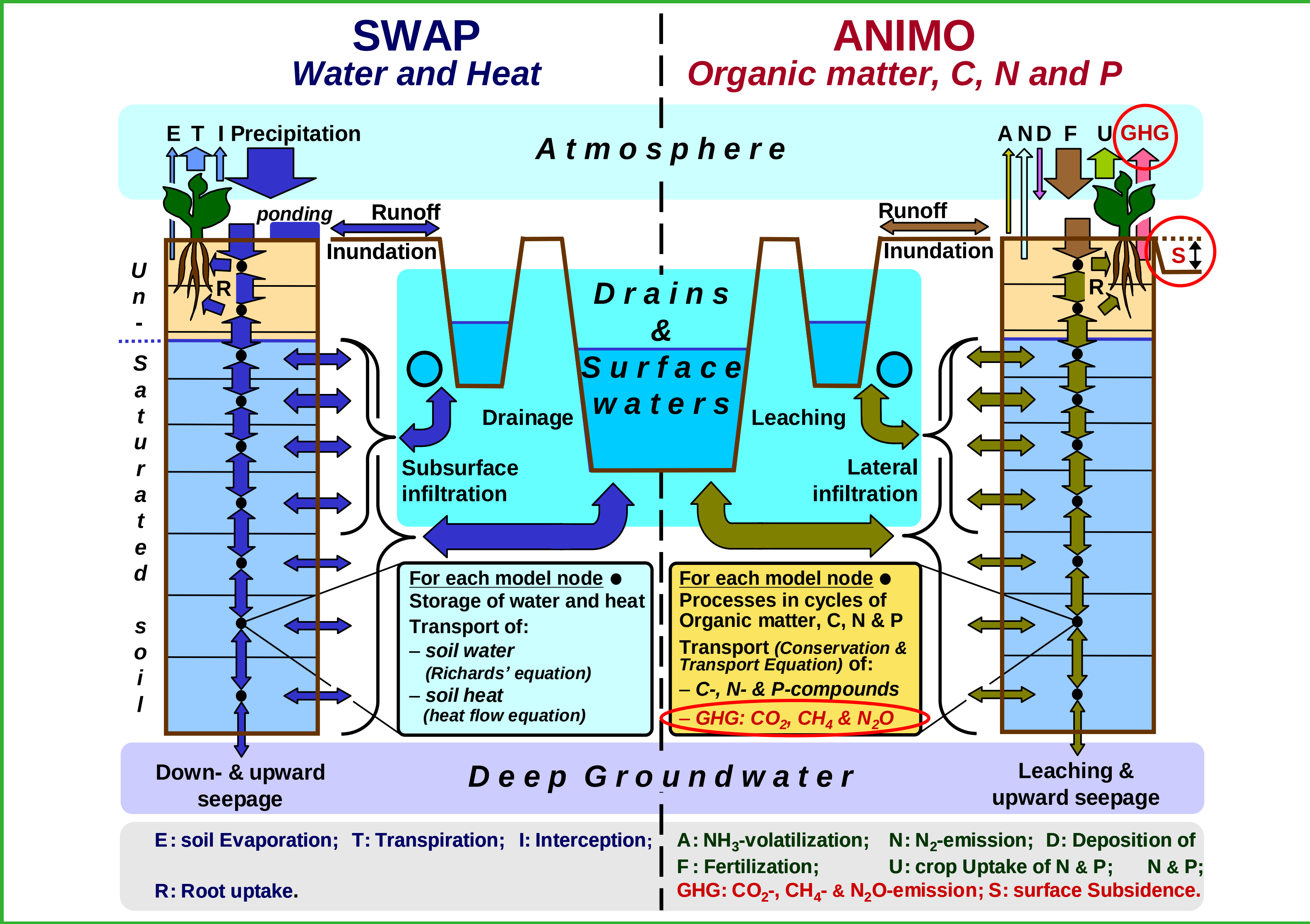
- Nutrients
- Process based
- Dynamic
- One dimensional
- Nutrient cycles & transport&conservation

Drainage/submerged infiltration: Pseudo 2D

Sulfate added



SWAP-ANIMO model combination



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Model input

- Site specific, measured values:
  - SWAP:

    - hydraulic functions

    - precipitation
  - ANIMO:

    - soil content organic matter, C, N, and P-, Al-, Fe-oxalate

    - decomposition rates organic matter

    - info about fertilization (manure, mineral)
- Default, expert judgement, modelling similar peat soils, regional data bases etc.
  - Both models

Model calibration

- SWAP:
  - drainage, infiltration resistances ditches and drains
  - resistance vertical flow
  - ponding threshold for runoff

- ANIMO (roughly because of lack of data on nutrients in soil):
  - initial concentrations of N- and P-compounds and sulfate in soil moist and water

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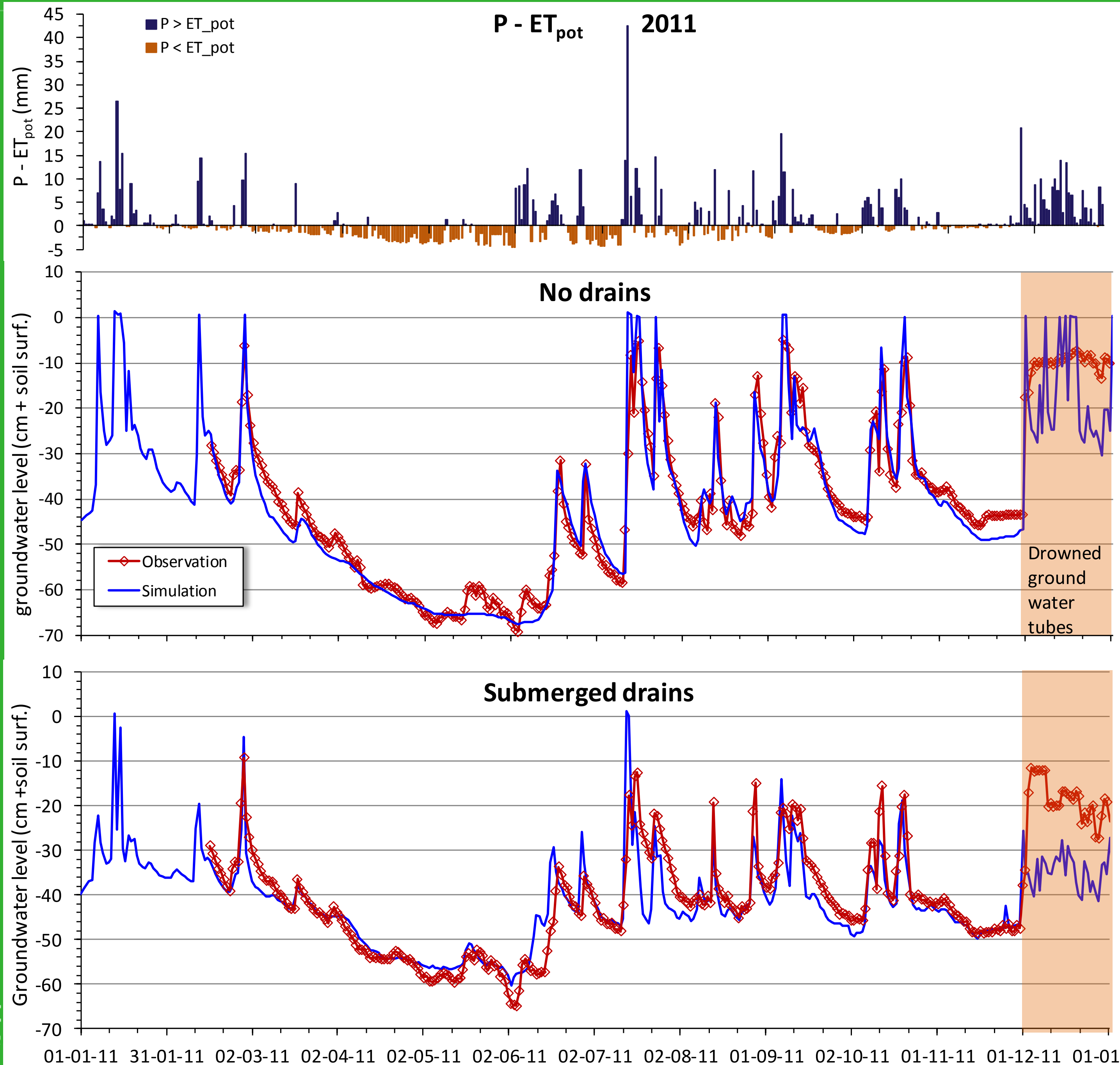
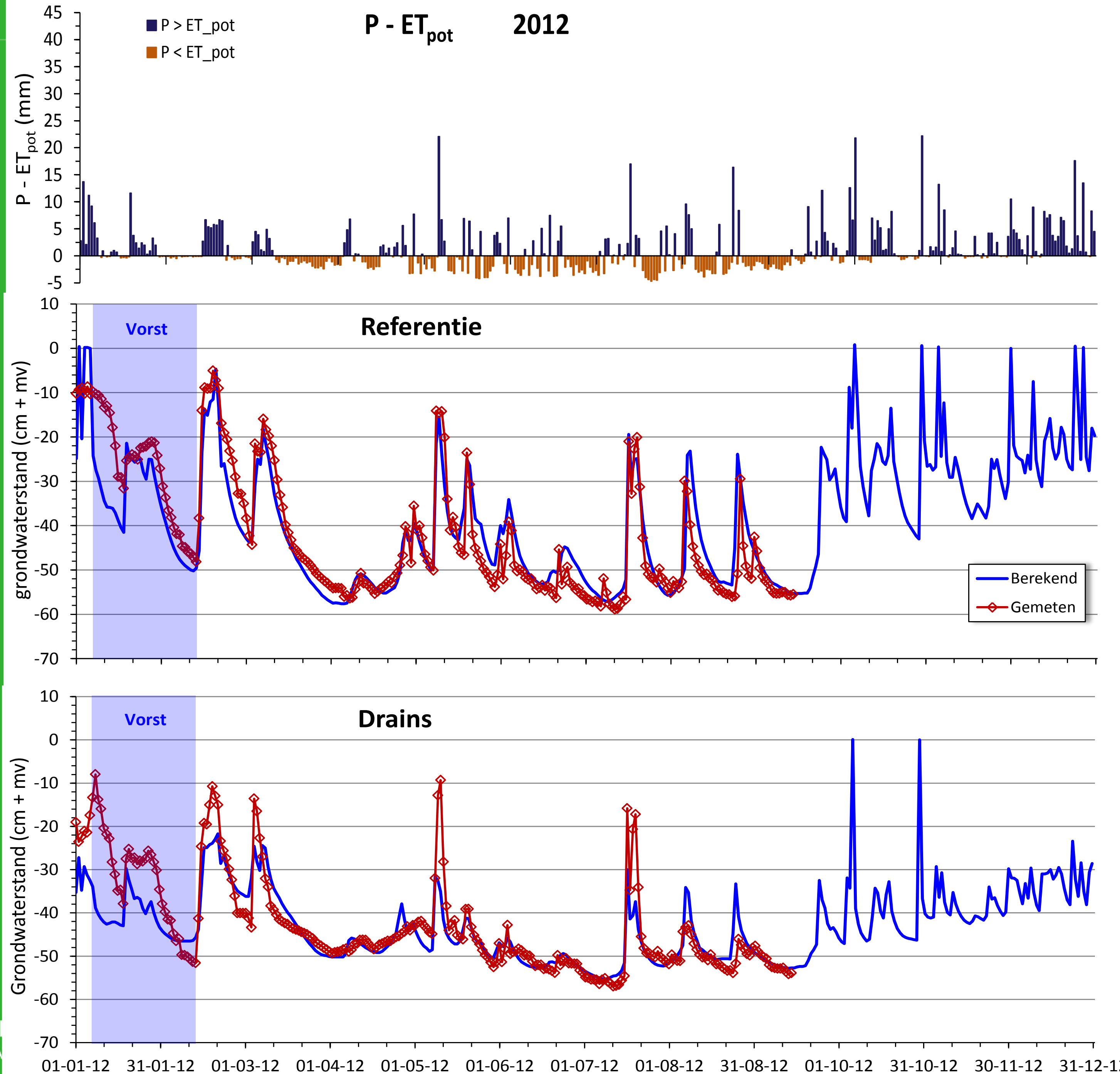
Calibration SWAP against ground-water levels 2011



Calibration SWAP against ground-water levels 2012



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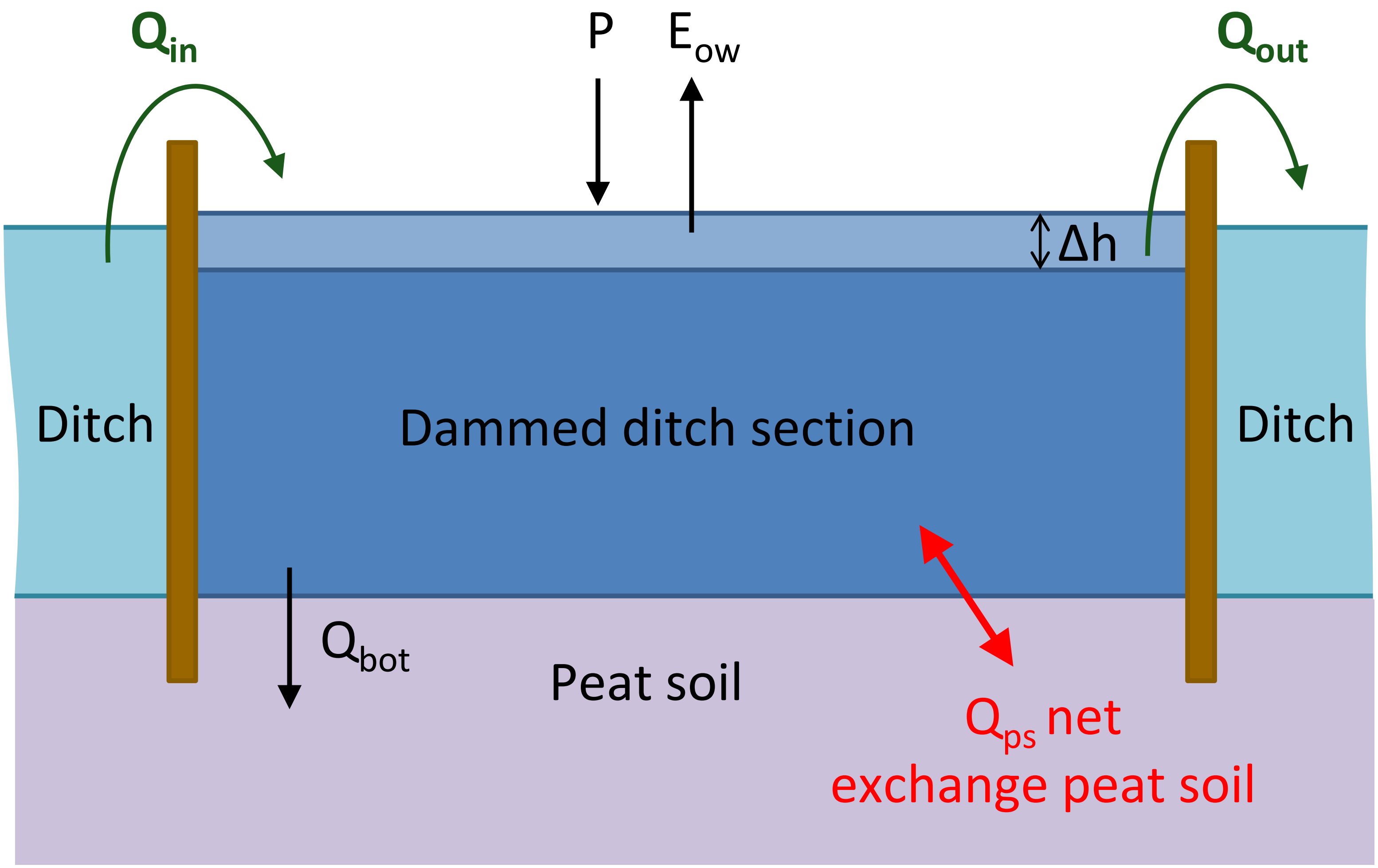
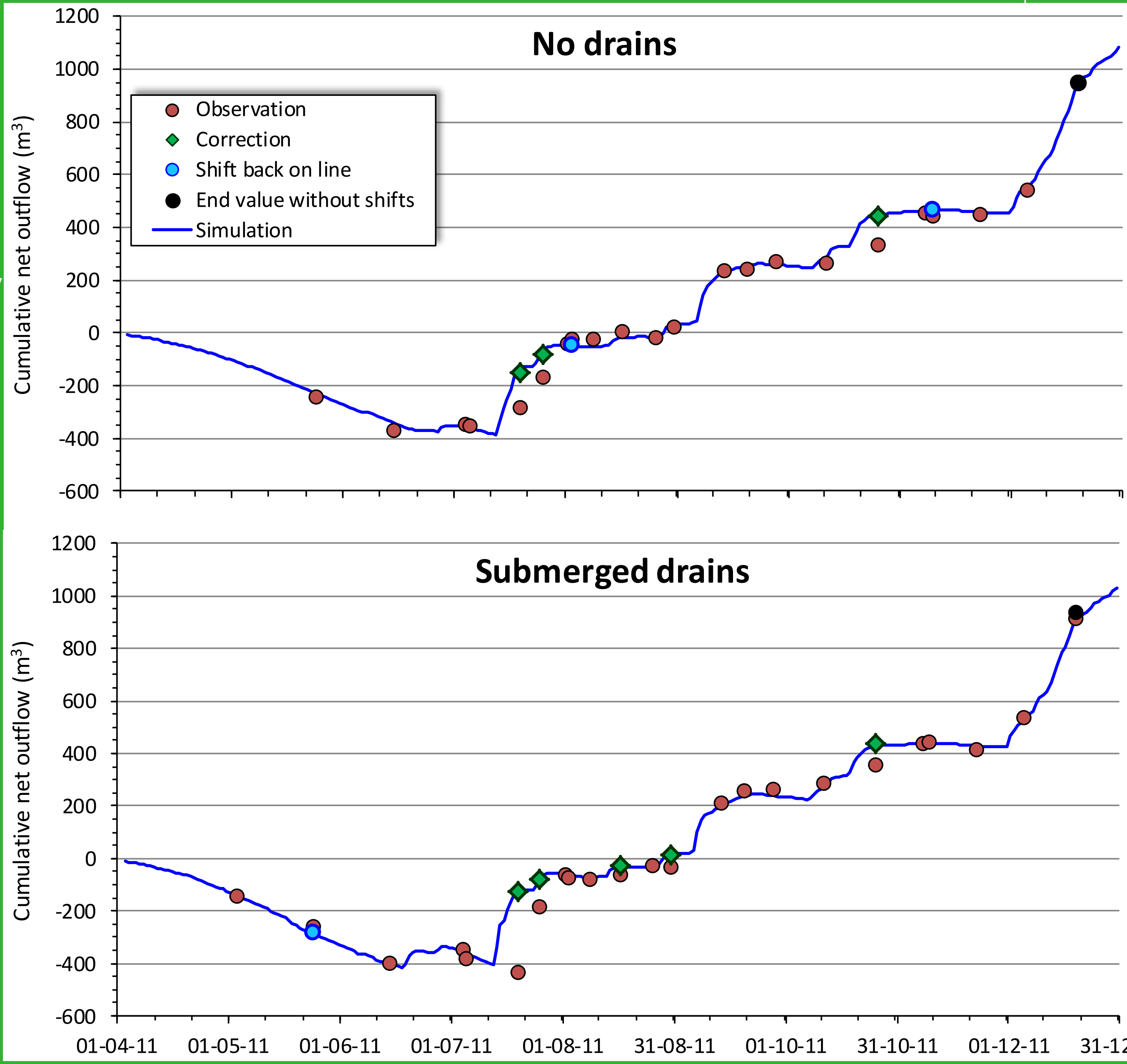
Calibration SWAP against net drainage/ infiltration (in/outflow dammed ditch section)



Calibration SWAP against net drainage/ submerged infiltration 2011



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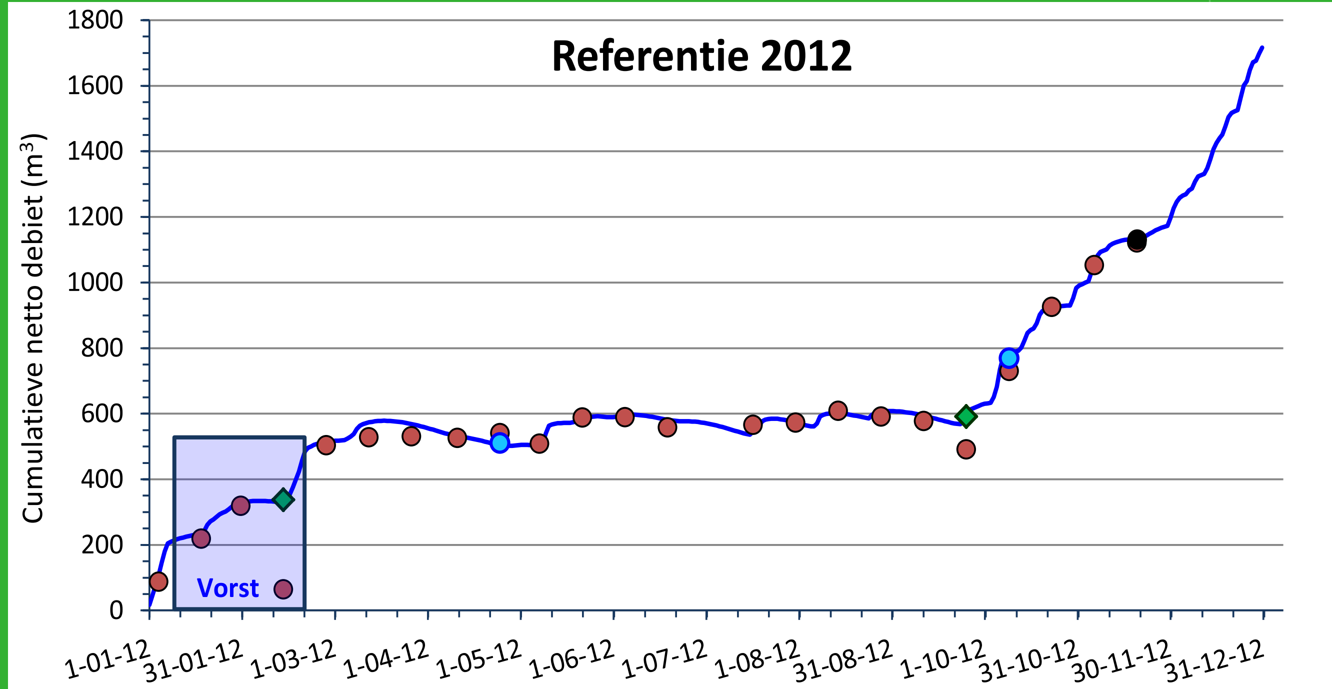
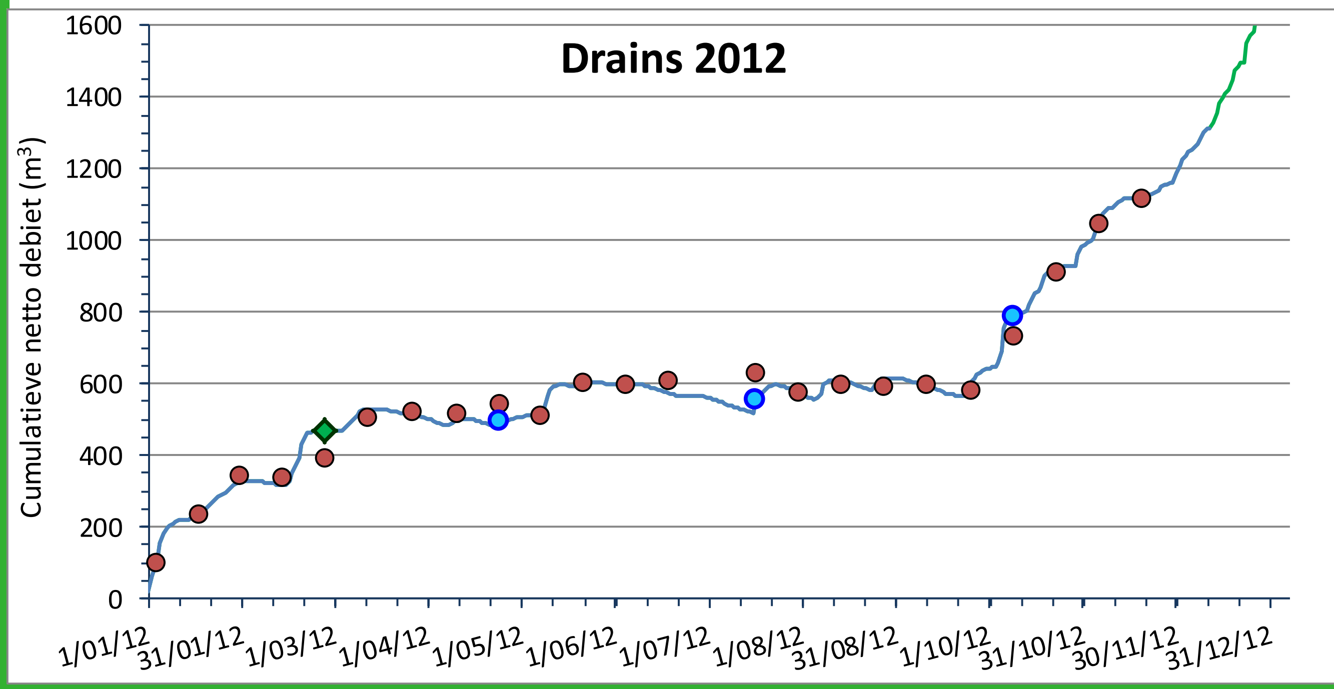
Calibration SWAP against net drainage/ submerged infiltration 2012





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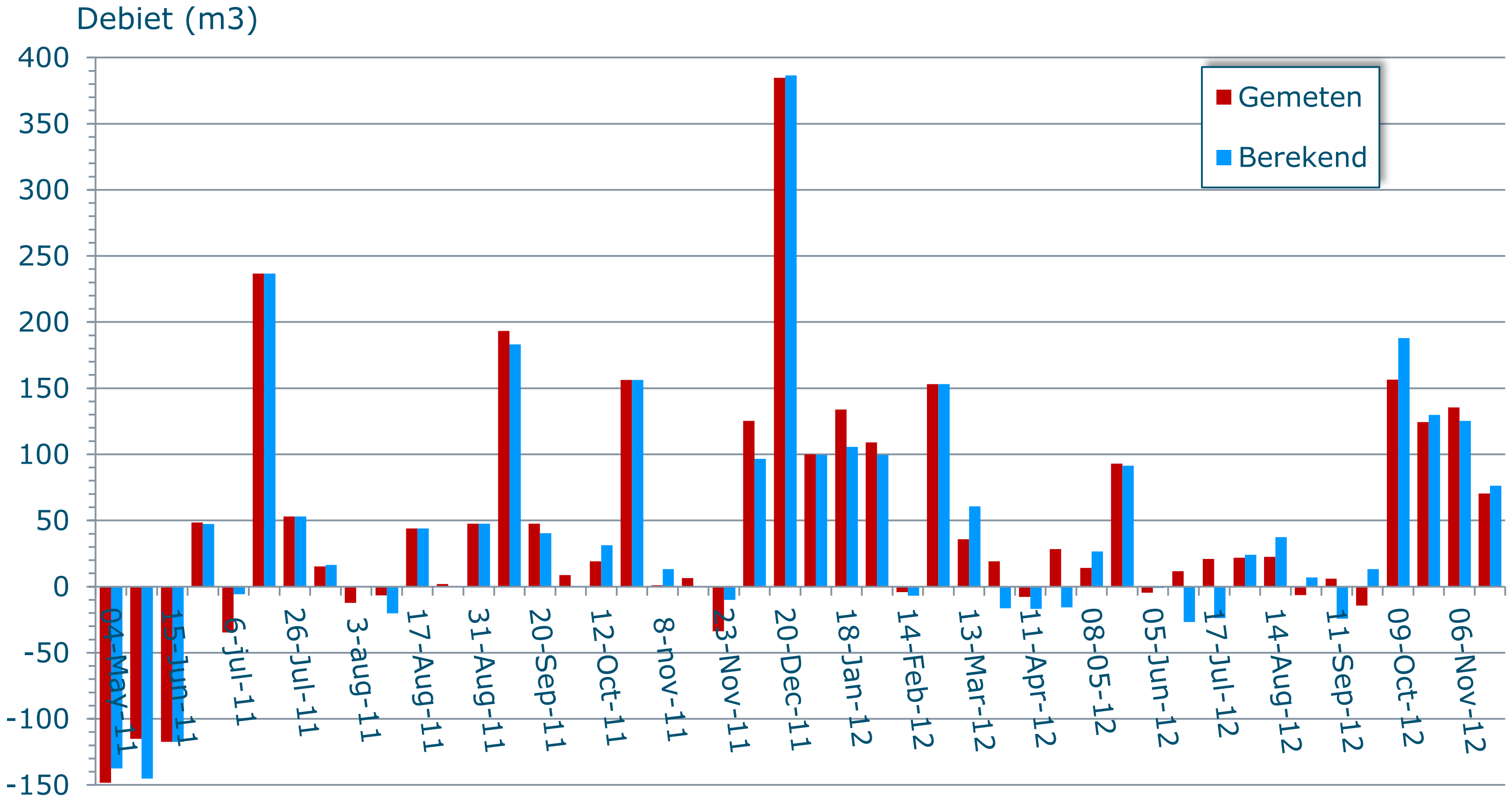
Statistical measures calibration SWAP

RMSE (Root Mean Squared Error)

Parameter	Year	No drains	Drains
Groundwater level	2011	4.9	5.3
(cm)	2012	5.3	4.9
	mean	5.1	5.1
Drainage/infiltration	2011&2012		
(m^3)		22	23
(% total flow)		1.1	1.1

Basis for RMSE drainage/submerg. infiltration

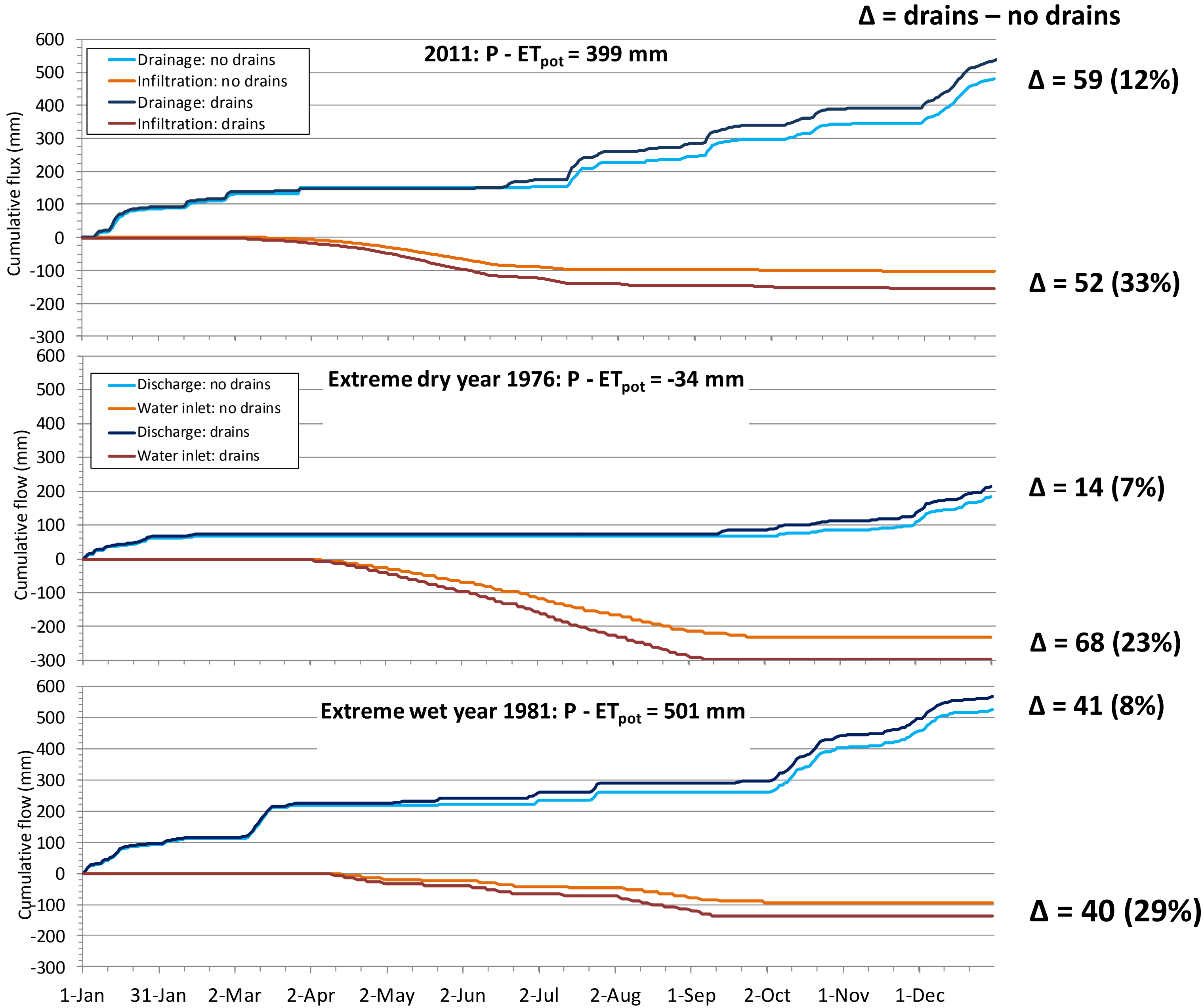


Calibration ANIMO against estimated nutrient loads to surface water in winter

Nutrient	No drains		Drains	
	Estimated	ANIMO	Estimated	ANIMO
Phosphorus (kg P /ha)	2.28	2.30	1.94	1.70
Nitrogen (kg N /ha)	16.1	16.0	16.3	15.0
Sulfate (kg SO_4 /ha)	158	155	159	155

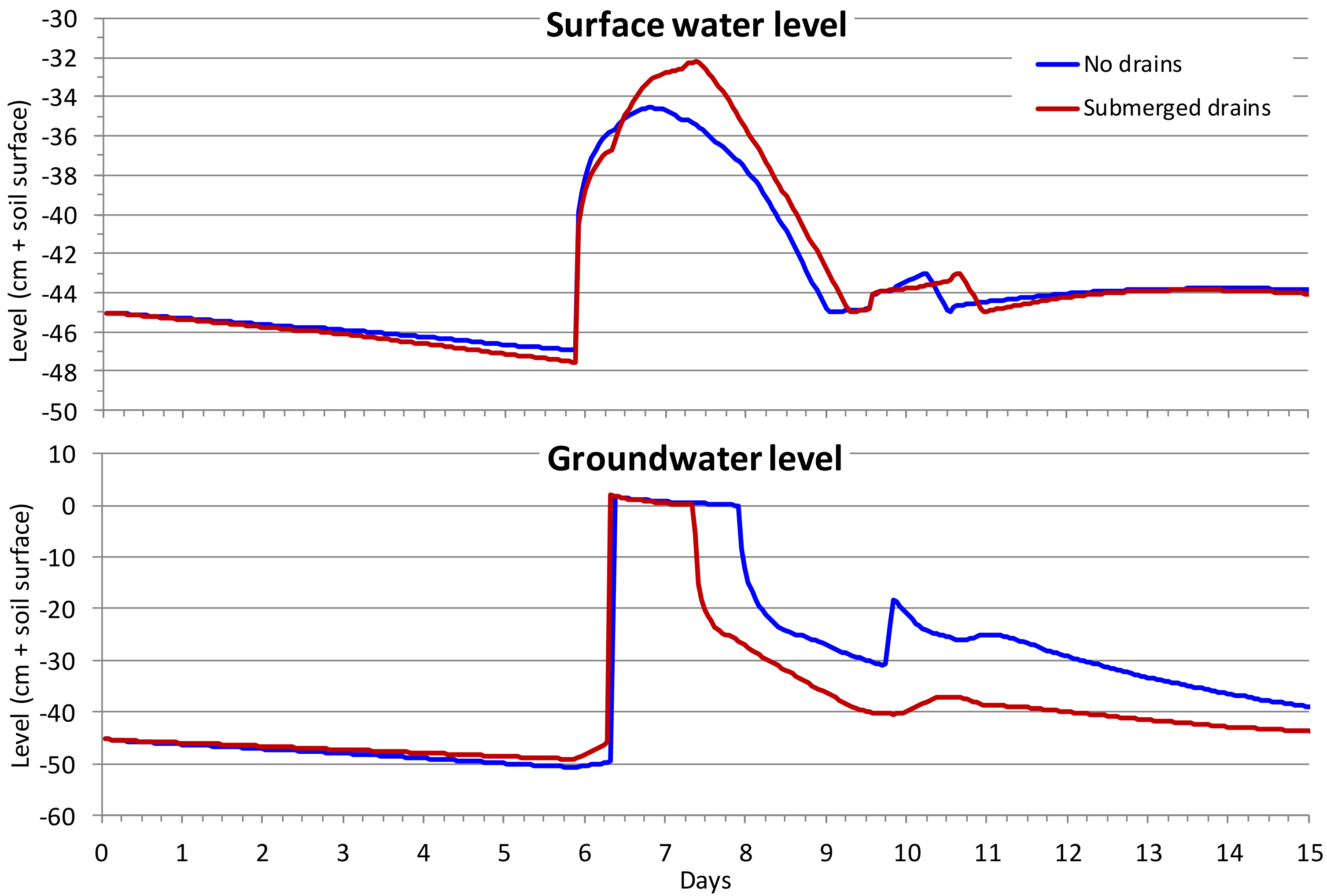
Not very reliable because disturbed soil during drainage

Q1 Drainage/infiltration and discharge/water inlet

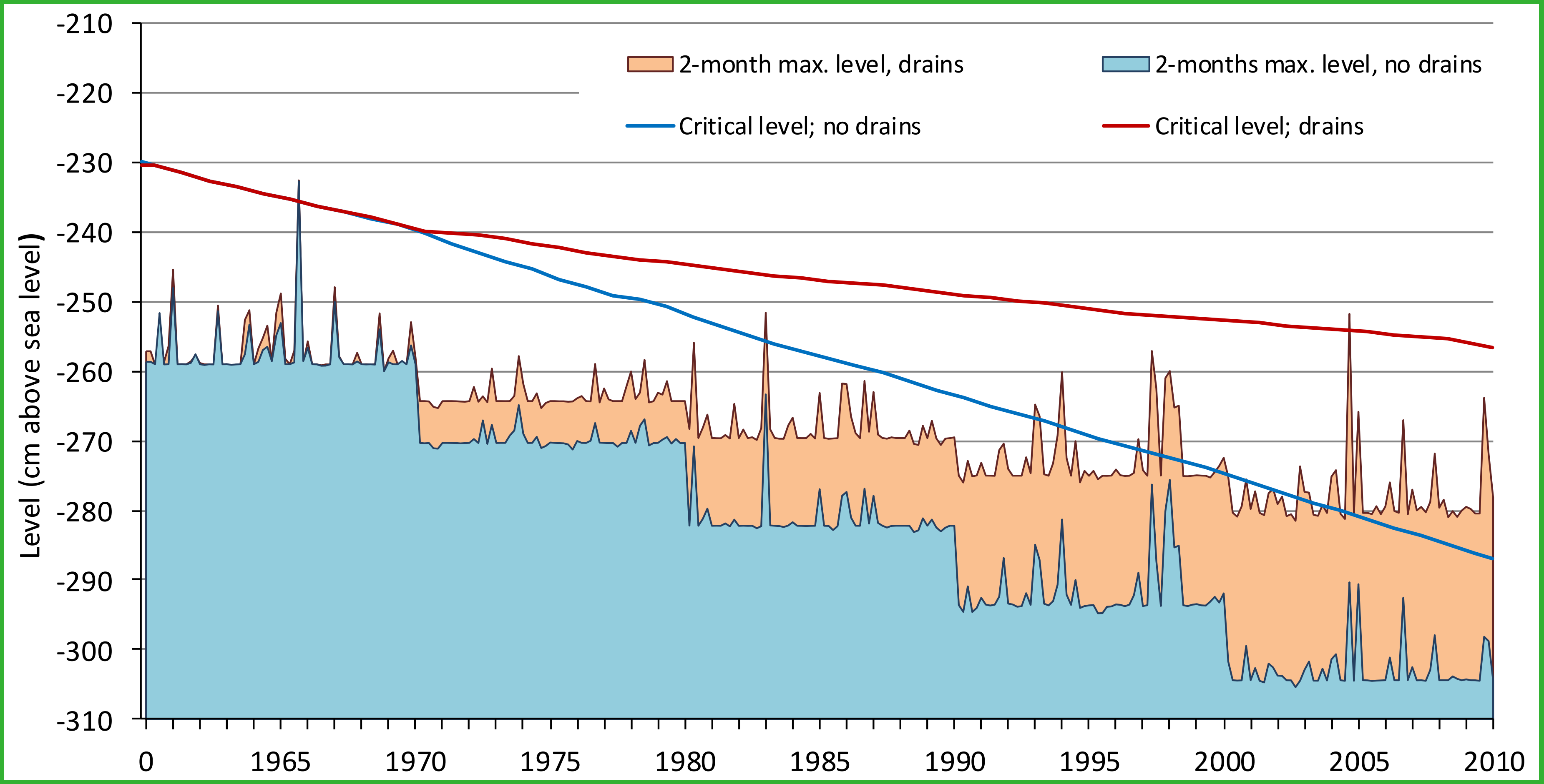


Q2 Flooding: extreme precipitation event

shower of 48.5 mm in one hour
maximum pump capacity of 10 mm per day



Q2 Flooding: long term, 50 years



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Q3 nutrient loading

Nutrient	Scenario year	Absolute values								Differences			
		Net loads				Concentrations				Drains - No drains			
		No drains		Drains		No drains		Drains		net loads		concentrat.	
		year	sumr	year	sumr	wint	sumr	wint	sumr	jaar	sumr	wint	sumr
Phosphorus	**1976**	0.66	-0.40	0.67	-0.43	0.57	1.12	0.54	0.81	0.01	-0.03	-0.03	-0.31
	1981	3.41	0.26	3.05	0.22	0.65	0.70	0.57	0.57	-0.36	-0.04	-0.08	-0.12
Nitrogen	**1976**	8.1	-3.1	6.9	-3.4	6.0	10.3	5.0	7.4	-1.2	-0.4	-1.0	-2.9
	1981	26.9	2.5	24.7	2.2	5.1	6.0	4.5	4.9	-2.3	-0.3	-0.6	-1.1
Sulphate	**1976**	143	-47	66	-71	102	5	60	22	-78	-24	-42	18
	1981	187	5	174	-1	38	38	36	32	-13	-7	-2	-6

Classes (%):	< -25	-25 – -15	-15 – -5	-5 – 5	5 – 15	15 – 25	> 25

<u>Govering processes:</u>

P: sorption, stronger under drier winter conditions

N: mineralisation, less under wetter summer conditions

SO_4: pyrite oxidation, less under wetter summer conditions

All: depth of drains in relation to peak concentrations

Conclusions: answers to the three questions

According to the models, applying submerged drains will:

A1

increase drainage (12%) and especially submerged infiltration (33%), and consequently water discharge (8%) and water inlet (23-29%). The latter can become a problem in the future climate.

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Conclusions: answers to the three questions

A2

rise peaks in surface water level during heavy showers, but only a few cm. High groundwater tables will be lowered much (days) faster by drains which benefits the agricultural use of the fields.

A3

decrease loading of surface water with P, N and SO_4 up to more then 25% (loads and leaching concentrations). SO_4 is the most sensitive; and vulnerable in combination with low ditch water levels.

Thank you for your attention

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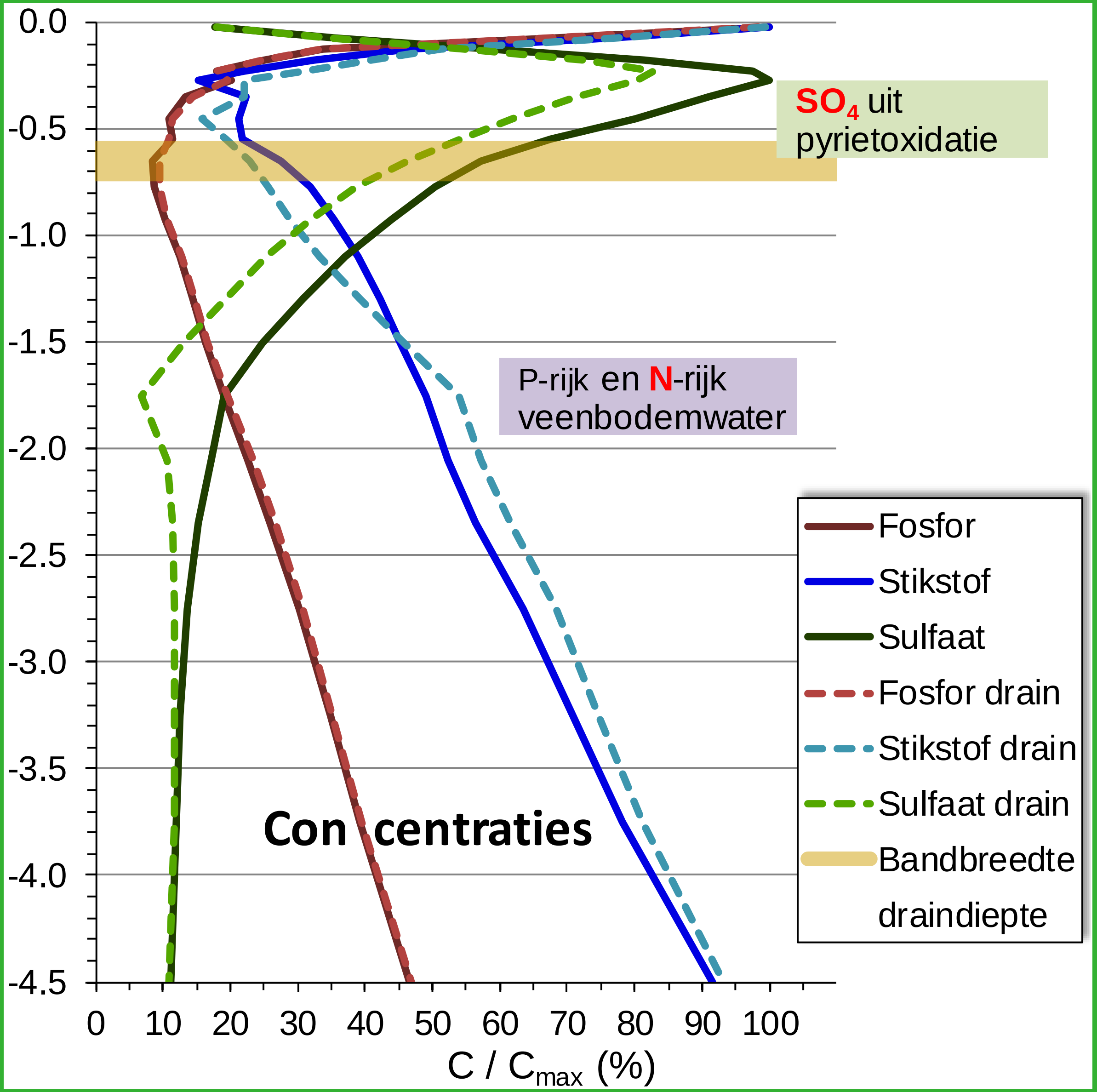

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