Simulaties van gewasopbrengst met SWAP-WOFOST voor Waterwijzer Landbouw

Projectteam Waterwijzer Landbouw

Inhoud

Aanleiding

Procesmodel

Resultaat

WWL-producten

Doorontwikkeling

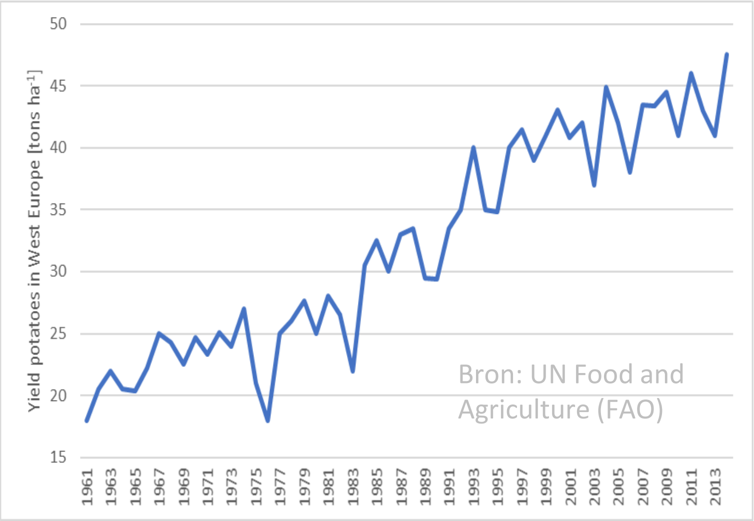
Validatie

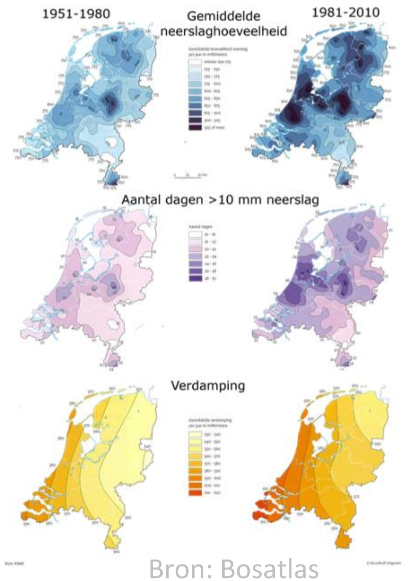
WATERwijzer Landbouw

Aanleiding

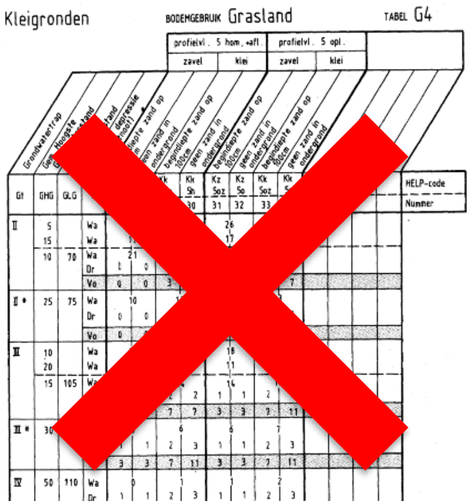
Doelstelling

Wat is het: Systeem voor bepalen van relaties tussen hydrologische condities en landbouwkundige gewasopbrengsten.





Bron: Bosatlas van het klimaat



Actualisatie HELP-tabellen

HELP-tabellen zijn toe aan actualisering.
van Bakel (2004)

HELP-tabellen is niet meer van deze tijd.
van Bakel (2011)

Actualisatie HELP-tabellen m.b.v. SWAP-WOFOST.
Bartholomeus (2013)

WATERwijzer Landbouw

Waterwijzer Landbouw

Wat is het: Systeem voor bepalen van *klimaatbestendige* relaties tussen hydrologische condities en landbouwkundige gewasopbrengsten.

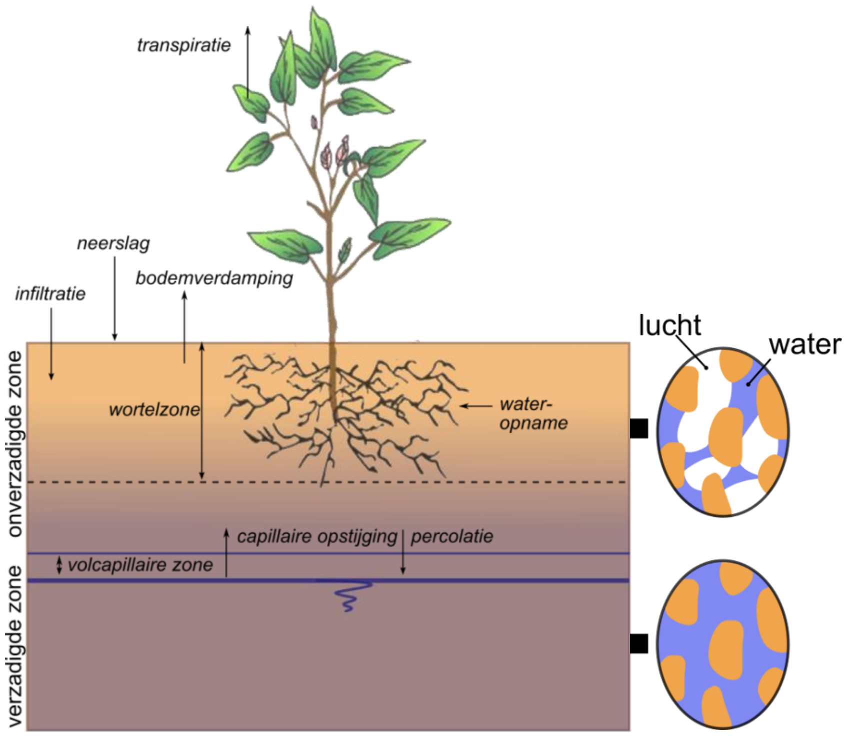
- ter vervanging van de huidige beschikbare systemen (HELP, TCGB, AGRICOM, Waternood)

Uitgangspunten:

- Gebruik van een procesmodel
- Reproduceerbaar en uitbreidbaar
- Bestaande kennis
- Geen correctiefactoren achteraf

Procesmodel

Procesmodel



Bartholomeus et al., 2008

SWAP-WOFOST

SWAP

Soil, Water, Atmosphere and Plant

(Van Dam, 2000; Kroes et al., 2017)

WOFOST

World Food Studies

(Boogaard et al., 2014; de Wit et al., 2019)

SWAP-WOFOST

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SWAP 50 years: Advances in modelling soil-water-atmosphere-plant interactions

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ARTICLE INFO

Handling Editor - Dr. B.E. Clothier

Keywords:
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Drought stress
Hydraulic properties
Oxygen stress
Root water uptake
Soil water balance

ABSTRACT

This paper highlights the evolution and impact of the SWAP model (Soil – Water – Atmosphere – Plant), which was initiated by R.A. Feddes and colleagues fifty years ago, in 1974. Since then, the SWAP model has played a crucial role in the advancement of agrohydrology. This paper highlights some major advances that have been made, especially focussing on the last fifteen years. The domain of the SWAP model deals with the simulation of the soil water balance in both unsaturated and saturated conditions. The model solves the Richards equation using the water retention and hydraulic conductivity functions as described by the Van Genuchten – Mualem equations. Bimodal extensions of the Van Genuchten - Mualem relationships have been implemented, as well as modifications near saturation and addressing hysteresis. An important sink term in the Richards equation is root water uptake. Crop development plays an important role in a robust simulation of root water uptake. That is why a link has been made with the dynamic crop growth model WOFOST. Instead of using a prescribed crop development, a distinction between potential and actual crop development is calculated by reducing the potential photosynthesis as a result of water or oxygen stress. Since the early days of SWAP, empirical and macroscopic concepts have been used to simulate root water uptake. Recently two process-based concepts of root water uptake and oxygen stress have also been implemented. Another important sink-source term in the Richards equation is the interaction with artificial drains. In SWAP, drainage can be simulated by either using prescribed or simulated drain heads and simulation of controlled drainage with subirrigation is possible. Finally, we briefly elaborate on three studies using SWAP: water stresses in agriculture in the Netherlands, regional water productivity in China, and controlled drainage with subirrigation. We finish discussing promising developments for the near future.

Quantification of the impact of hydrology on agricultural production as a result of too dry, too wet or too saline conditions

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Review

25 years of the WOFOST cropping systems model

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ARTICLE INFO

Keywords:
Simulation Model
Regional scale
open source
yield forecasting

ABSTRACT

The WOFOST cropping systems model has been applied operationally over the last 25 years as part of the MARS crop yield forecasting system. In this paper we provide an updated description of the model and reflect on the lessons learned over the last 25 years. The latter includes issues like system performance, model sensitivity, spatial model setup, parameterization and calibration approaches as well as software implementation and version management. Particularly for spatial model calibrations we provide experience and guidelines on how to execute calibrations and how to evaluate WOFOST model simulation results, particularly under conditions of limited field data availability.

As an open source model WOFOST has been a success with at least 10 different implementations of the same concept. An overview is provided for those implementations which are managed by MARS or Wageningen groups. However, the proliferation of WOFOST implementations has also led to questions on the reproducibility of results from different implementations as is demonstrated with an example from MARS. In order to certify that the different WOFOST implementations and versions available can reproduce basic sets of inputs and outputs we make available a large set of test cases as appendix to this publication.

Finally, new methodological extensions have been added to WOFOST in simulating the impact of nutrients limitations, extreme events and climate variability. Also, a difference is made in the operational and scientific versions of WOFOST with different licensing models and possible revenue generation. Capitalizing both on academic development as well as model testing in real-world situations will help to enable new applications of the WOFOST model in precision agriculture and smart farming.

Contents lists available at ScienceDirect
Geoderma
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Quantitative land evaluation implemented in Dutch water management

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Simulation modelling
Meta-model
Crop yield assessment
Soil management
Agro-hydrology
Land use

ABSTRACT

Both in land evaluation and in water management quantitative methods, GIS and simulation modelling are well-known techniques for quantifying the effects of changes, such as land use or climate change. For hydrological management decisions information is often required on the effect of those decisions on agricultural production. To serve the needs of different types of users, like water authorities, provinces, drinking water companies and the National Department of Infrastructure and Water Management we developed a toolbox named WaterVision Agriculture as an instrument that can determine effects on crop yield and the farm economy as a result of drought, too wet or too saline conditions for both current and future climatic conditions.

WaterVision Agriculture is based on the hydrological simulation model SWAP, the crop growth model WOFOST and farm management and economic assessments such as DairyWise for dairy farming. The WaterVision Agriculture (WVA) project resulted in two products, namely i) an easily applicable tool (also called the WVA-table) and ii) the operational models for hydrology and crop growth SWAP and WOFOST for calculating effects on field scale combined with calculating farm economic results and indirect effects. SWAP simulates water transport in the unsaturated zone using meteorological data, boundary conditions (like groundwater level or drainage) and soil parameters. WOFOST simulates crop growth as a function of meteorological conditions and crop parameters. Using the combination of these process-based models and methods for describing crop management and economic value we derived a meta-model, i.e. a set of easily applicable simplified relations for assessing crop growth as a function of soil type and groundwater level. These relations are based on multiple model runs for at least 72 soil units and the possible groundwater regimes in the Netherlands. The easily applicable tool (WVA-table) uses this meta-model.

Applying the meta-model of WaterVision Agriculture should allow for better decisions on land use or soil and water management because the instrument can help to quantify the effects of changes in climate, land use, hydrological conditions or combinations of these effects on agricultural production.

Heinen et al., 2024; de Wit et al., 2019; Hack-ten Broeke et al., 2016; 2019

Resultaat

Opbrengstderving

Kwantificeren van opbrengstderving:

Verschil tussen potentiele en actuele gewasopbrengst

- Potentiele gewasopbrengst
  - Alleen afhankelijk van meteorologische omstandigheden
- Actuele gewasopbrengst
  - Reductie van de potentiele gewasopbrengst als gevolg van ongunstige hydrologische omstandigheden

Opbrengstderving

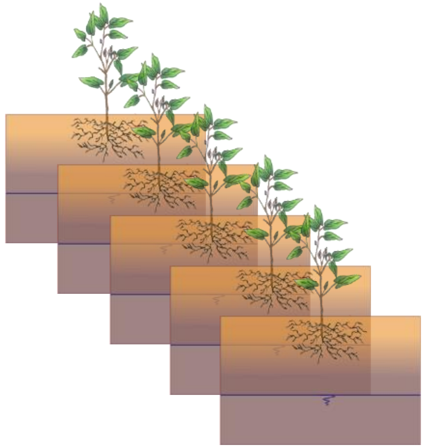
Specificatie van opbrengstderving

- Directe effecten (transpiratiereductie):
  - Direct te relateren aan transpiratiereductie
  - Te droog, te nat (zuurstofstress) of te zout
- Indirecte effecten:
  - Andere vormen van schade gerelateerd aan hydrologische omstandigheden (verkort groeiseizoen)

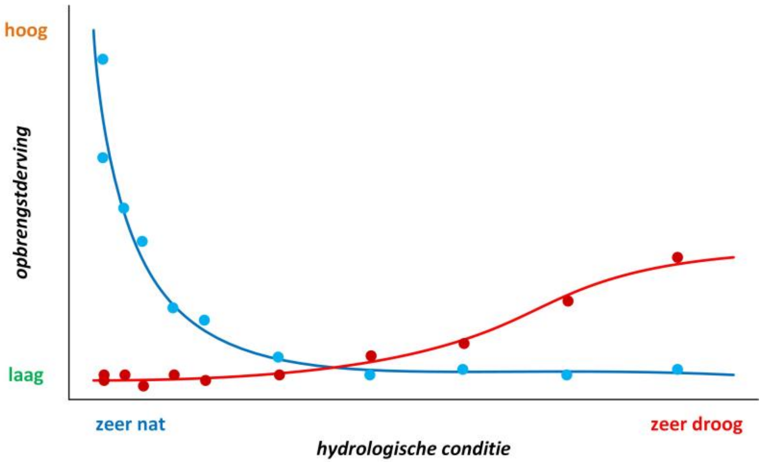
WWL-producten

WWL-producten

van complexe modellen naar eenvoudige toepassing



SWAP-WOFOST



WWL-metamodel

schade: 'droog'; bodem: '72'; gewas: 'maïs'; meteo: 'Eelde'; scenario: 'huidig klimaat'; ...

schade: 'nat'; bodem: '3'; gewas: 'gras'; meteo: 'de Bilt'; scenario: 'huidig klimaat'; ...

schade: 'nat'; bodem: '2'; gewas: 'gras'; meteo: 'de Bilt'; scenario: 'huidig klimaat'; ...

schade: 'nat'; bodem: '1'; gewas: 'gras'; meteo: 'de Bilt'; scenario: 'huidig klimaat'; ...

GHG / GLG	10	20	30	40	50	60
40	60					
50	44	34				
60	29	21	15			
70	18	13	8	3		
80	15	8	4	1		
90	15	7	3	1	0	
	...	...	...	...	...	...

WWL-tabel

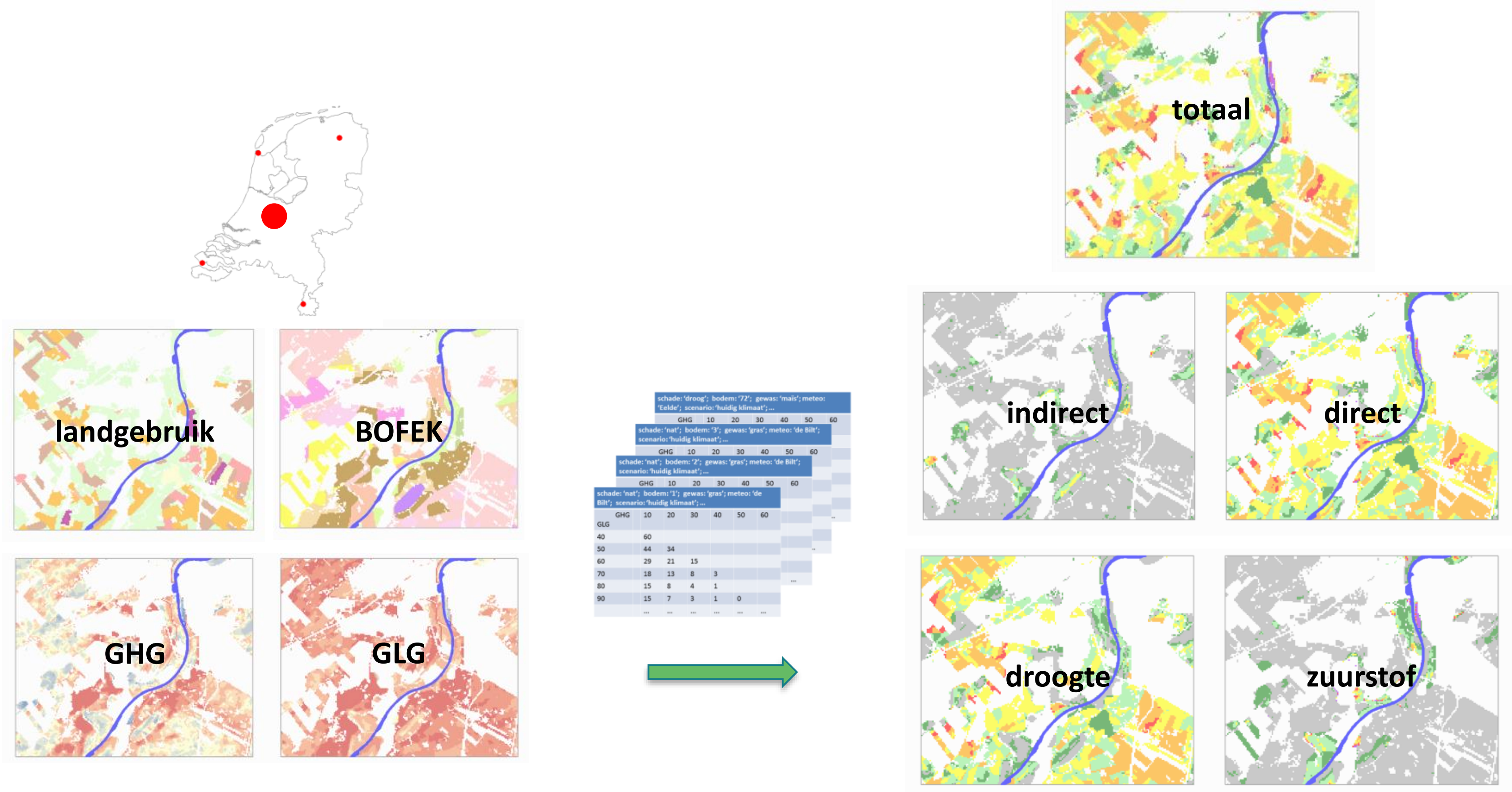
Afleiden WWL-metamodel

Variatie in metamodel (ploteigenschappen):

- Landgebruik (meest voorkomende gewassen)
- Bodem (BOFEK2020; Staringreeks 2018)
- Irrigatie
- Meteorologie (5 weerstations en 2 klimaatscenario's)
- Hydrologische condities (van zeer nat tot zeer droog)
- Zout (6 zoutconcentraties)

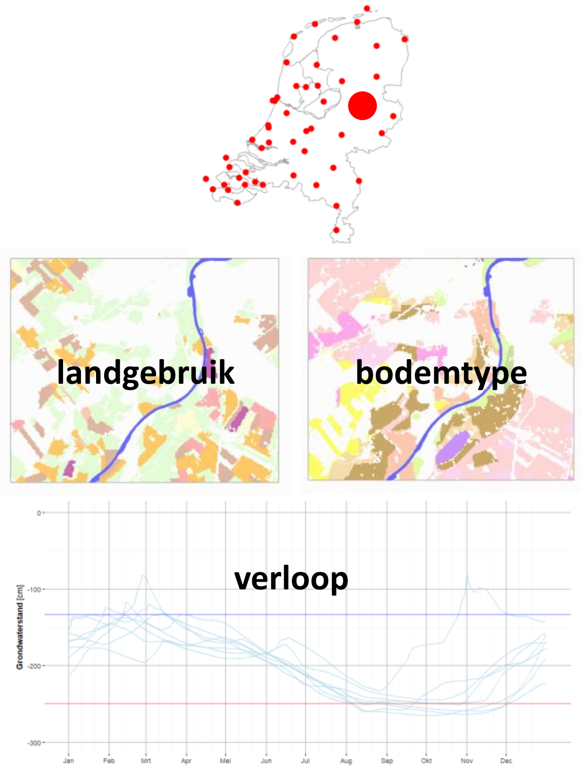
circa 1 miljoen berekeningen

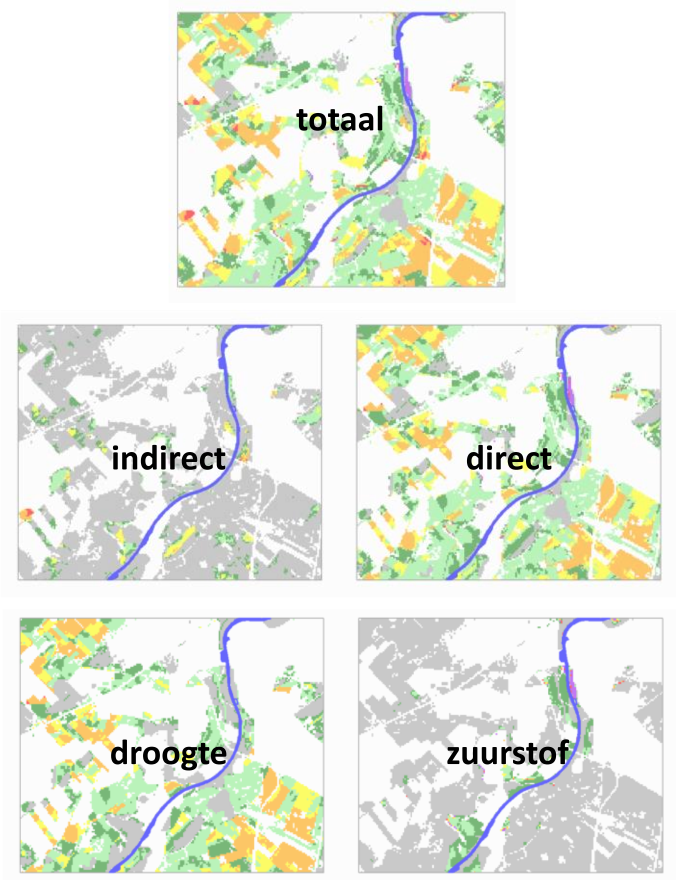
WWL-tabel



website: https://waterwijzerlandbouw.wur.nl/index.html

WWL-regionaal





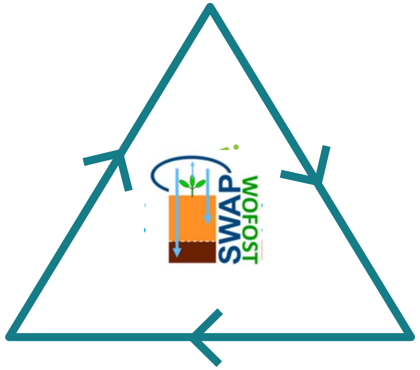
Doorontwikkeling

vanaf 2018

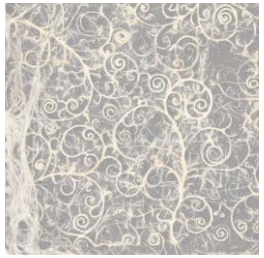
Waterwijzer Landbouw

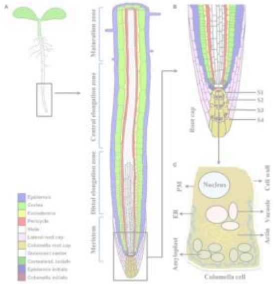
Invoer

Procesmodel



Procesbeschrijving





Ervaring

Aansturing

Product

WATERwijzer Landbouw

Recente ontwikkelingen

SWAP-WOFOST modelinstrumentarium

- Simulatie van wateropname
- Adaptieve wortelontwikkeling

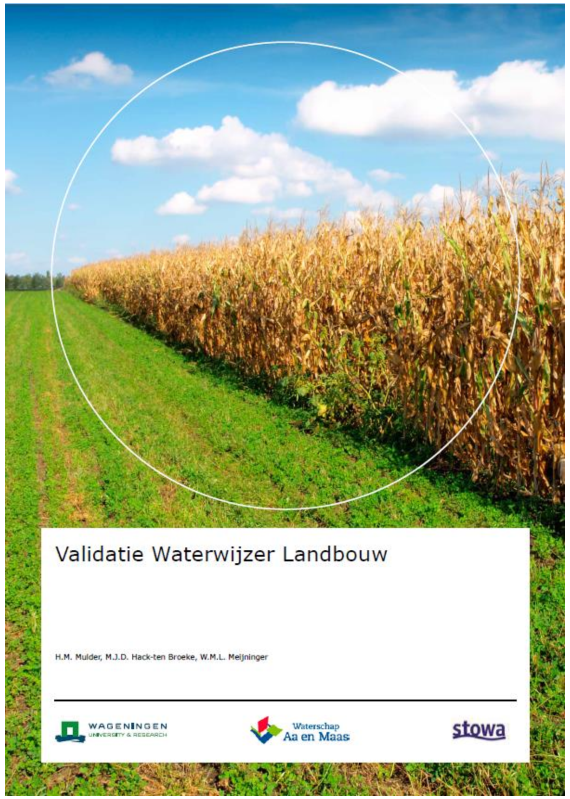
Heinen et al., 2023

Validatie

Validatie en vergelijking

Validatie en vergelijking:

- Vergelijking HELP
- Validatie veldproeven
- Vergelijking Groenmonitor



Mulder et al., 2023

Toekomst

VV-WWL

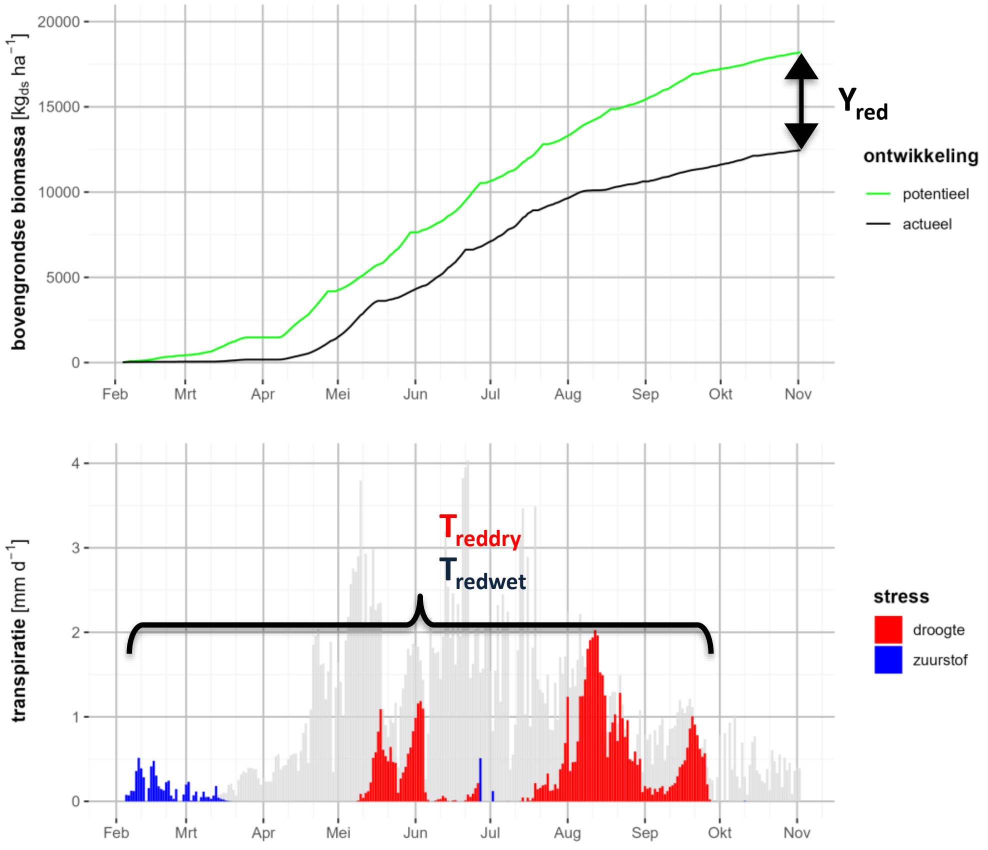
Verbeteren

- SWAP-WOFOST modelinstrumentarium:
  - Zuurstofdiffusie bij krimpscheuren
  - Specificatie gewasopbrengstderving
- WWL-metamodel:
  - Extrapolatie modelresultaten

Validatie

- Recente veldproeven (Tamara ten Den en Paul van Ravensbergen)
- Vergelijking Bedrijveninformatienet (BIN)

Specificatie gewasopbrengsderving



Waterwijzer Landbouw

(concept: transpiratiereductie)

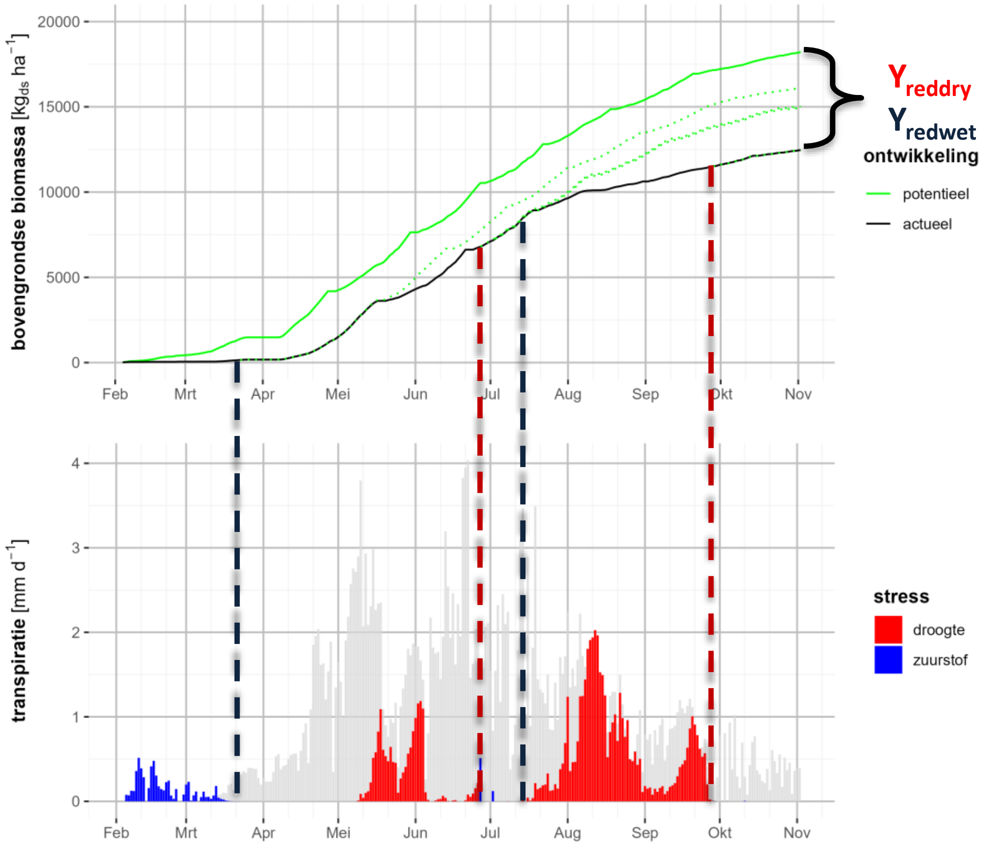
Gewasopbrengstderving

- Totaal: 31.6 %

Specificatie

- Droogtestress 28.5 %
- Zuurstofstress 3.1 %

Specificatie gewasopbrengsderving



Waterwijzer Landbouw

(concept dynamische gewasmodule)

Gewasopbrengstderving

- Totaal: 31.6 %

Specificatie

- Droogtestress 19.6 %
- Zuurstofstress 12.0 %

Dank voor de aandacht

Vragen?

WATERwijzer
Landbouw