Food and Agriculture Organization of the United Nations

International Network of Salt-Affected Soils

Modelling plant growth with AquaCrop

Dirk Raes
KU Leuven (Belgium)

Margarita Garcia-Vila
IAS, CSIC (Spain)

1. AquaCrop model overview

2. Simulation of soil water and salt balance

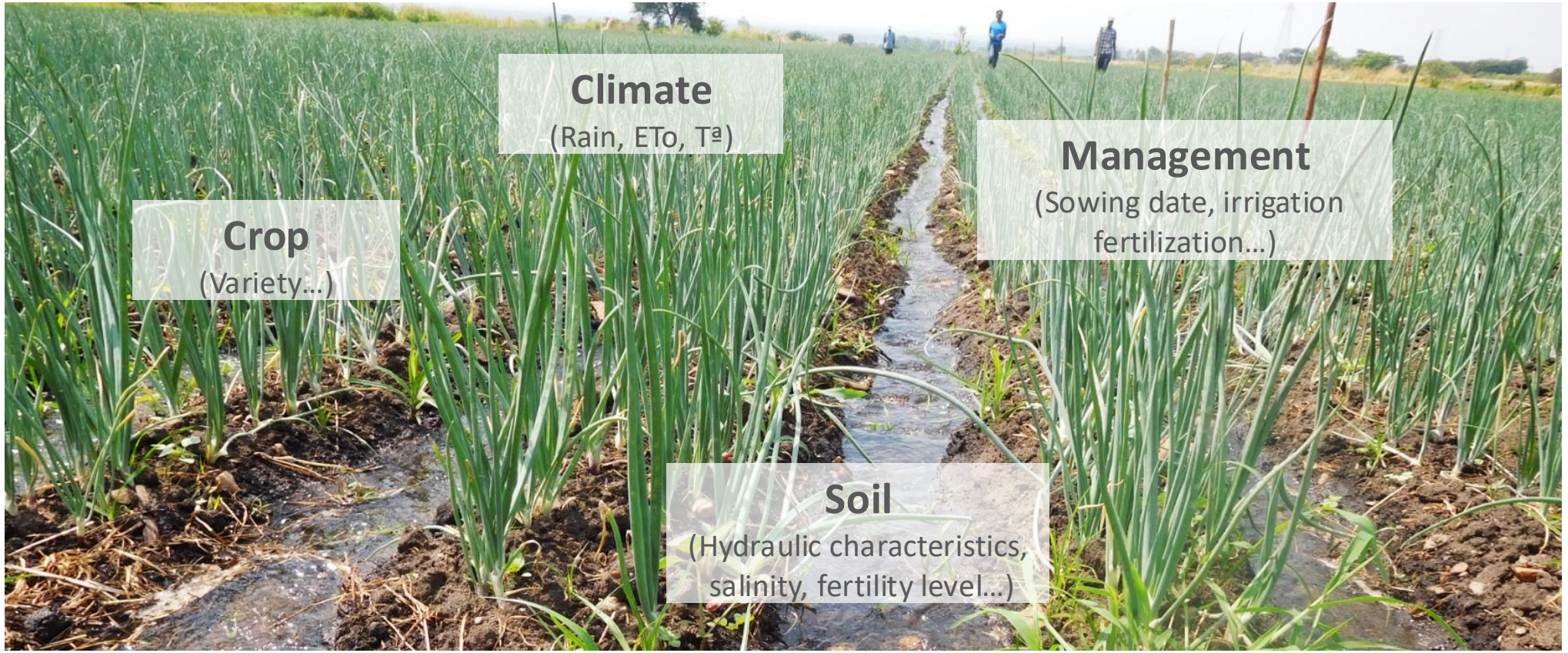
3. Crop production and irrigation management under saline conditions

1. AquaCrop model overview

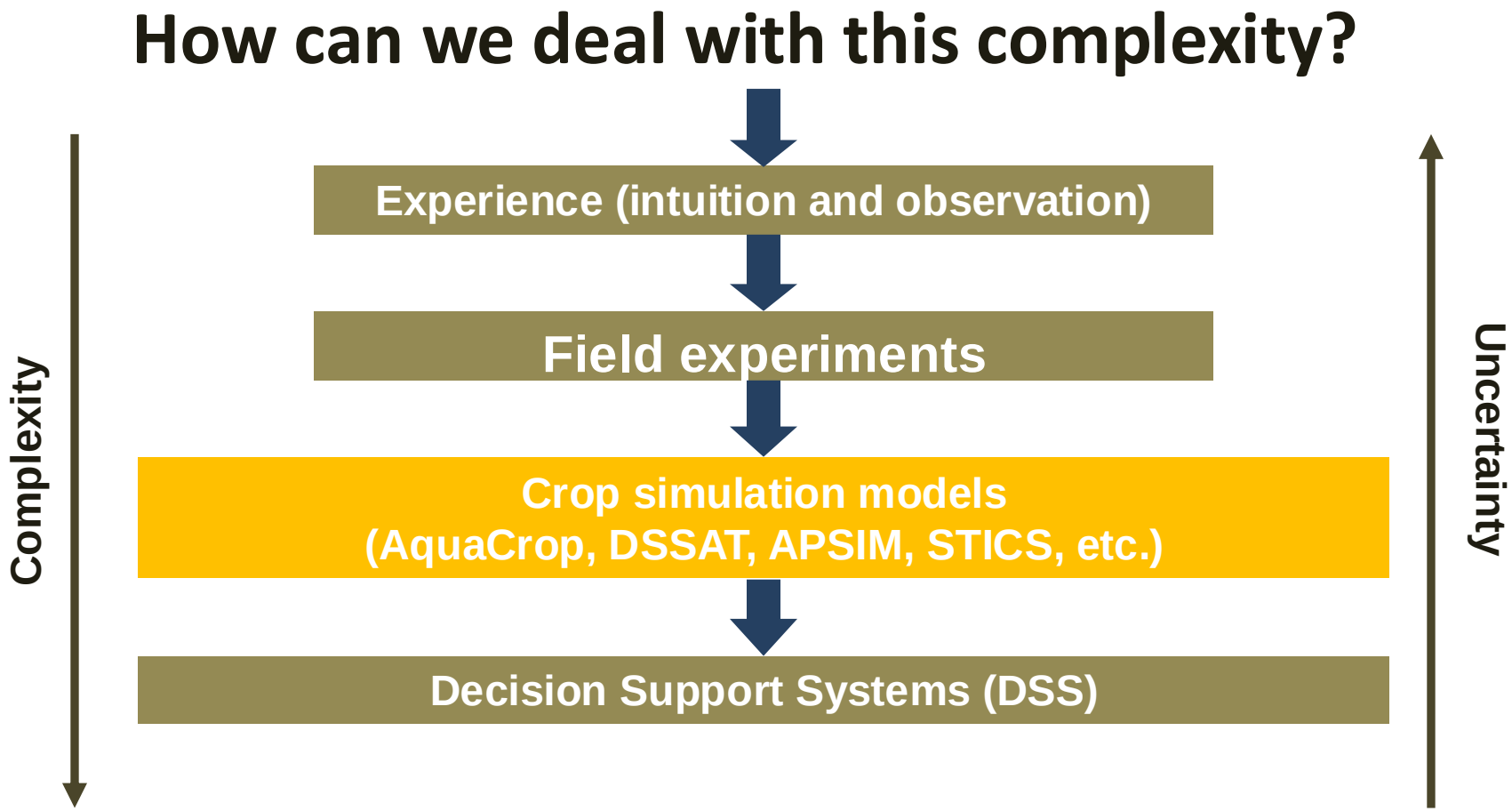
2. Simulation of soil water and salt balance

3. Crop production and irrigation management under saline conditions

Soil and water management is a complex activity

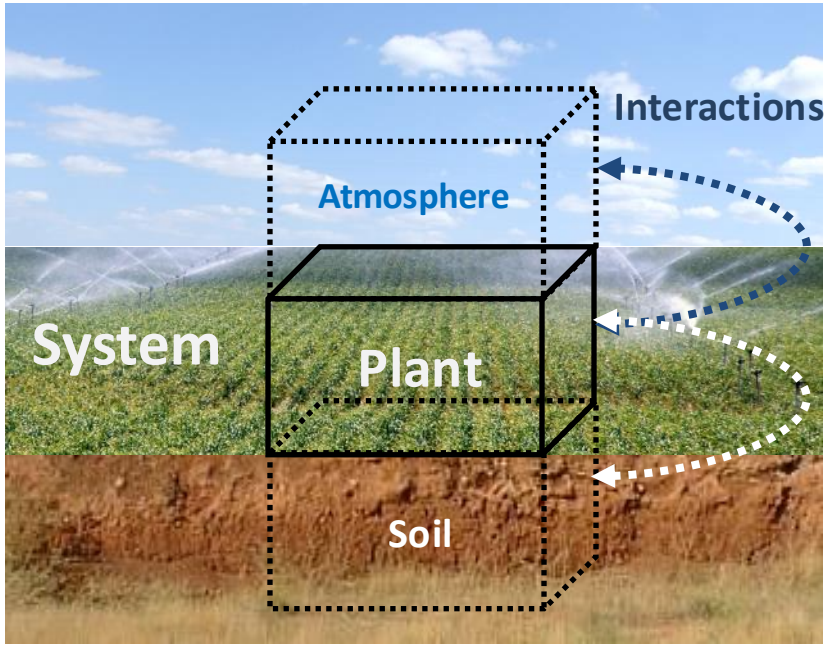


AquaCrop model overview

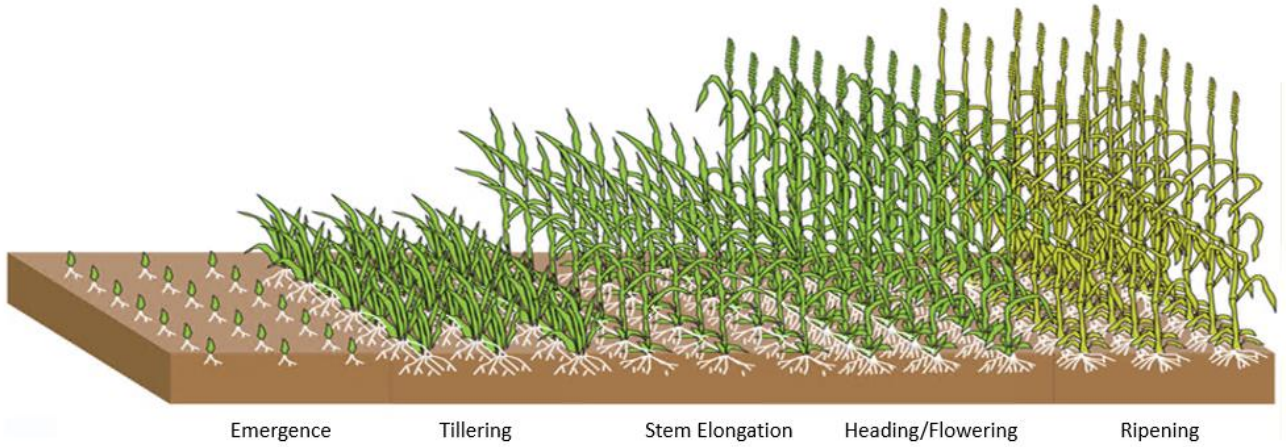


AquaCrop model overview

Crop models



G x E x M Interactions in Agricultural Systems



Model Inputs
Meteorological Variables
Soil Properties
Cultivar Parameters
Management

Model Processes
Phenological Development
Light Interception and Utilization
Growth Allocation to Crop Organs
Root Distribution
Soil Water & Nutrients Dynamics
Evapotranspiration
Environmental Stresses
Effects of Elevated CO_2

Key Model Outputs
Crop Yield
Soil Properties
Water Balance Components

(ARS, USDA, 2024)

AquaCrop model overview

DSSAT

STICS

WOFOST

APSIM next generation

AQUACROP

ORYZA

a simulation model for nitrogen and carbon in agro-ecosystems monica

EPIC Environmental Policy Integrated Climate model

Need for a model to assess crop yield response to water

Food and Agriculture Organization of the United Nations

AquaCrop model overview

Water productivity model

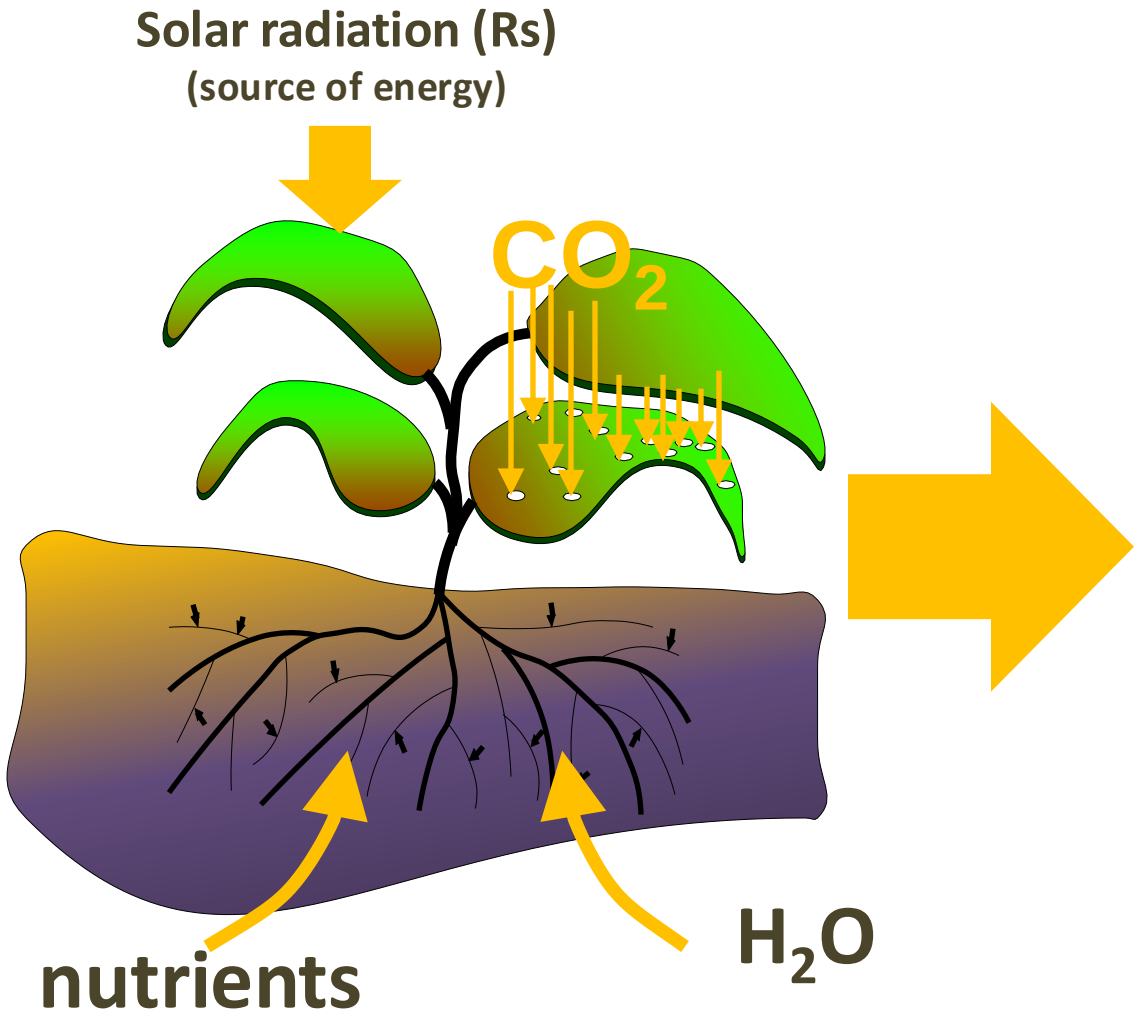
AQUACROP

Empirical + **Mechanistic**

Need for a model to assess crop yield response to water

Food and Agriculture Organization of the United Nations

Modelling approach



CROP SIMULATION MODELS

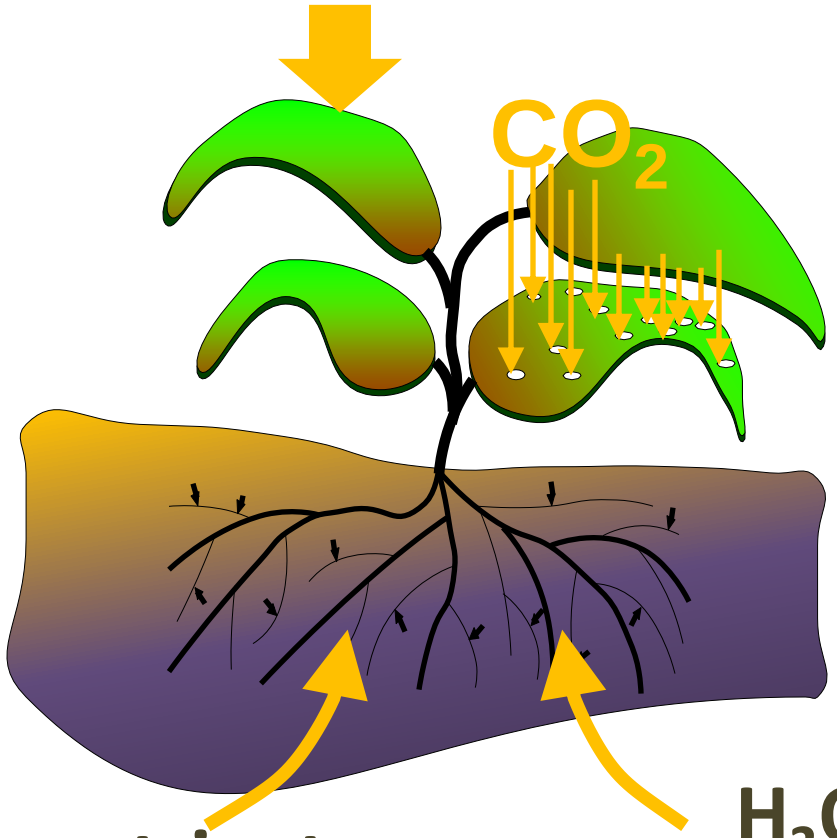
Type of growth engine

- carbon-driven
- solar-driven
- water-driven

AquaCrop model overview

Modelling approach

Solar radiation (Rs)
(source of energy)



Carbon-driven growth engine

Intercepted solar radiation

↑ Carbon assimilation by the leaves photosynthetic process

$H_2O + CO_2 \rightarrow$ glucose + O_2

↓ Maintenance and growth respiration of the various organs

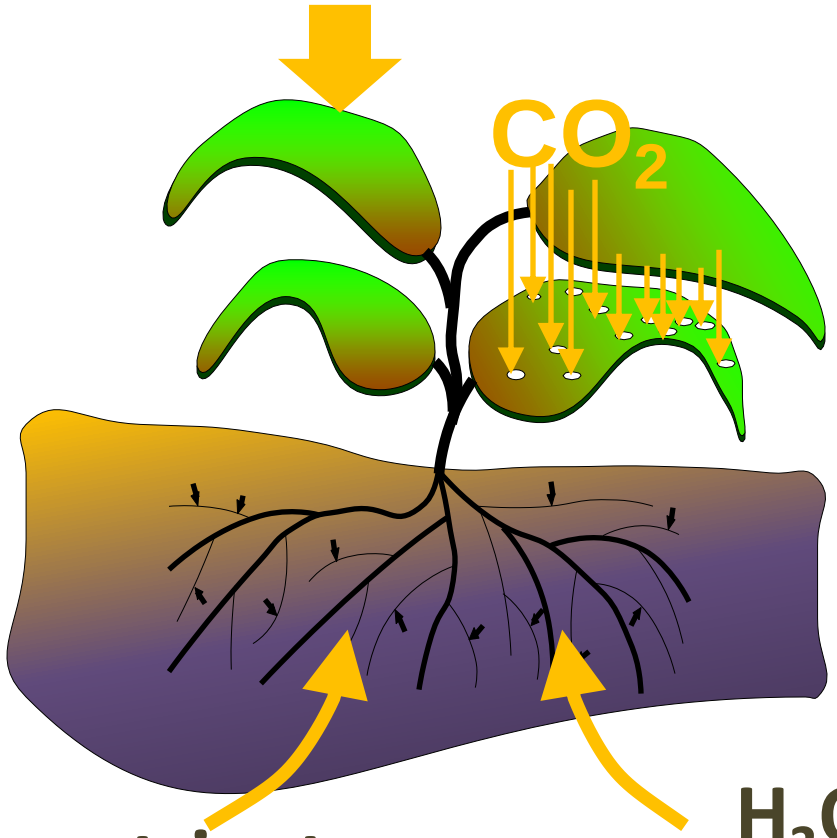
Production of structural biomass

[kgDM/m².day]

AquaCrop model overview

Modelling approach

Solar radiation (Rs)
(source of energy)



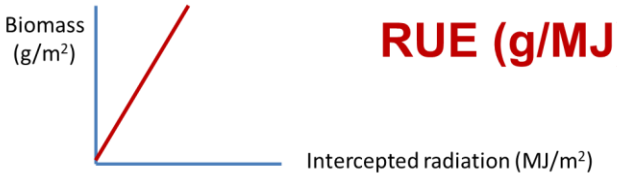
Solar-driven growth engine

Intercepted solar radiation

Carbon assimilation by the leaves photosynthetic process

Radiation Use Eficiecy

Maintenance and growth respiration of the various organs

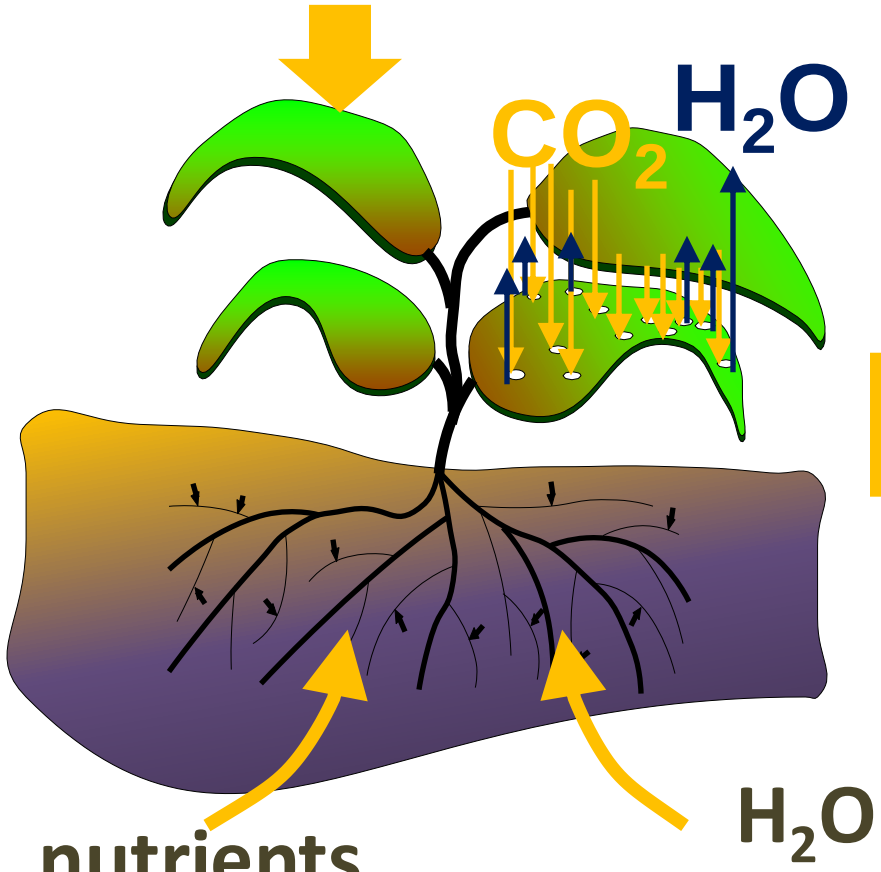


Production of structural biomass
[kgDM/m².day]

AquaCrop model overview

Modelling approach

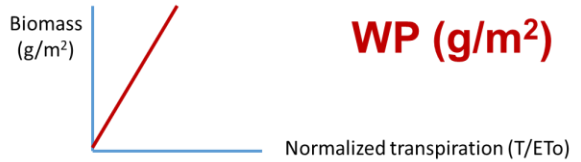
Solar radiation (Rs)
(source of energy)



Water-driven growth engine

Crop transpiration

Biomass water productivity

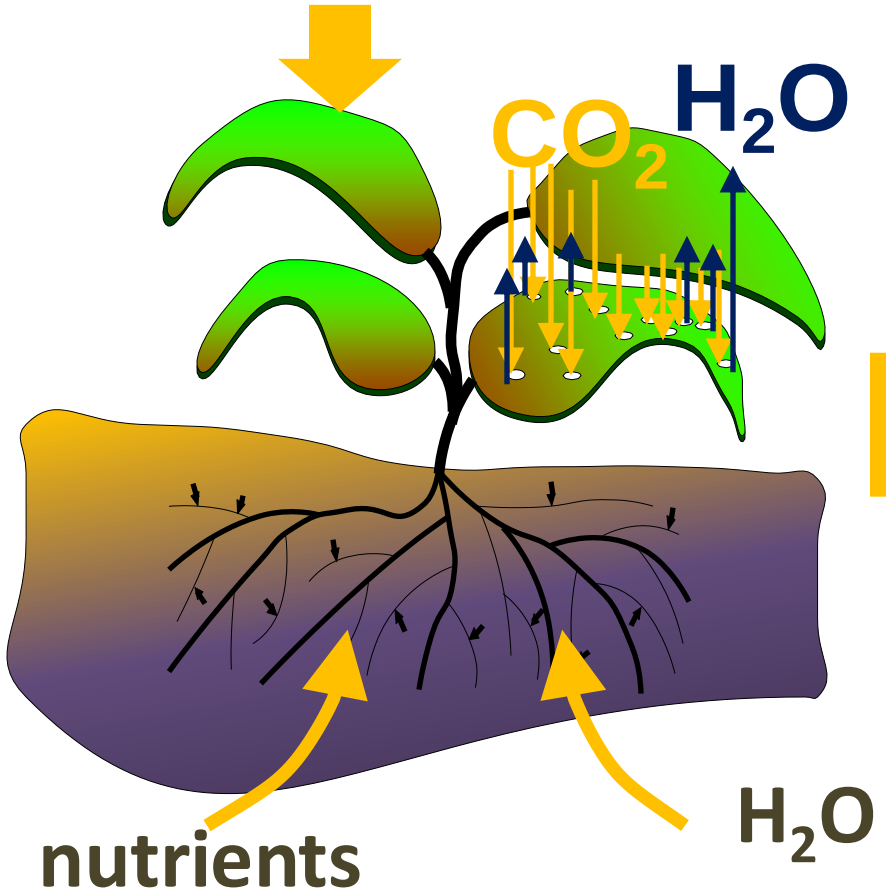


Production of structural biomass
[kgDM/m².day]

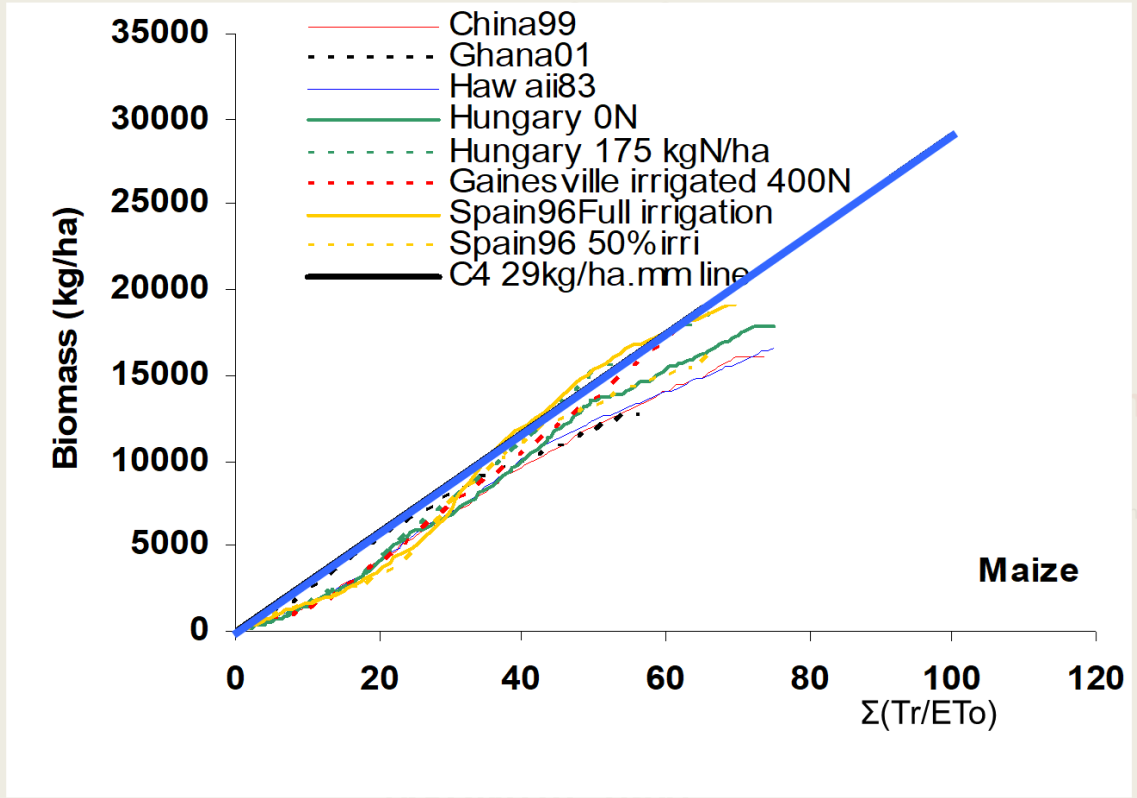
AquaCrop model overview

Modelling approach

Solar radiation (Rs)
(source of energy)



Water-driven growth engine



Data from ICASA, IAEA & UniMelb

AquaCrop model overview

Modelling approach

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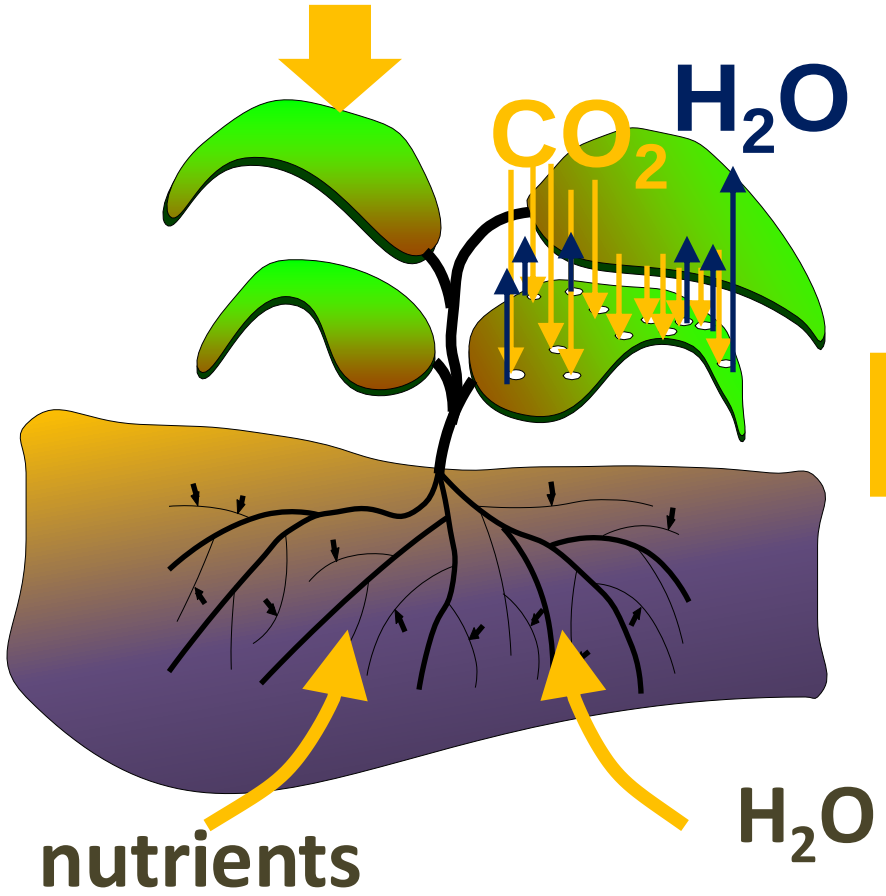
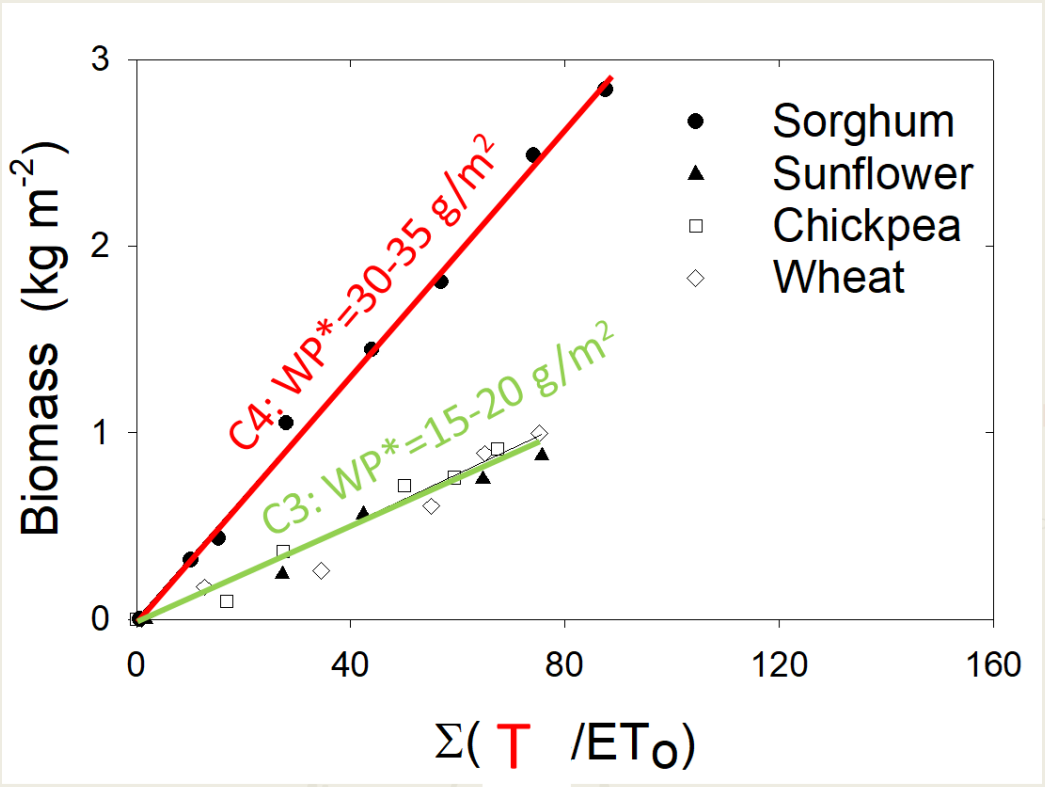
(source of energy)



Water-driven growth engine



Steduto et al. (2007)

AquaCrop model overview

Water productivity model

Empirical + Mechanistic

- ✓ Uses a relatively small number of parameters
- ✓ Requires only commonly available inputs
- ✓ Balance between simplicity, accuracy and robustness

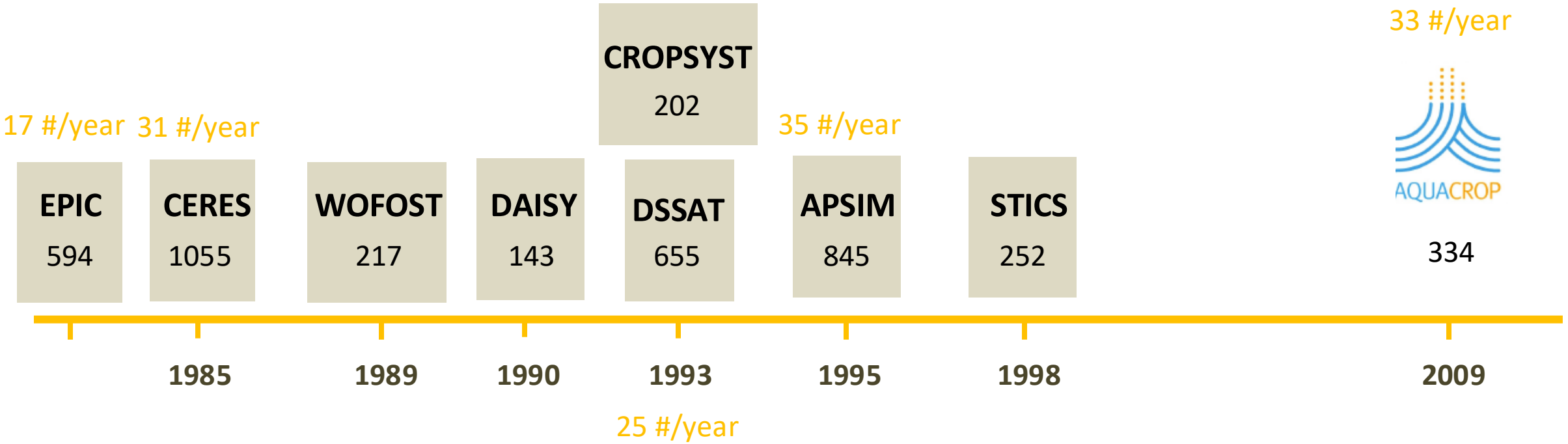
General Concepts

Based on:
- Plant physiology processes
- Soil water budgeting processes

Is widely applicable with acceptable accuracy

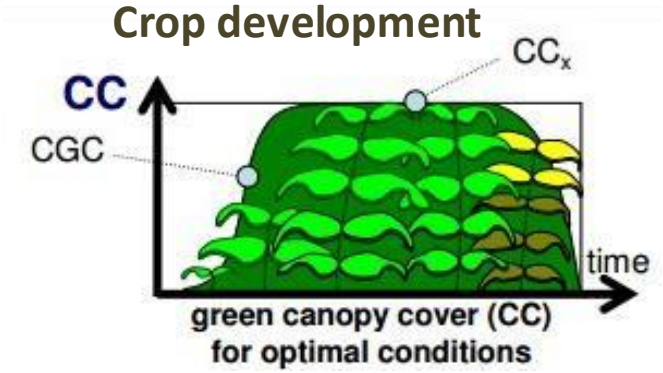
AquaCrop model overview

Number of publications



Source: *Salman et al. (2021)*

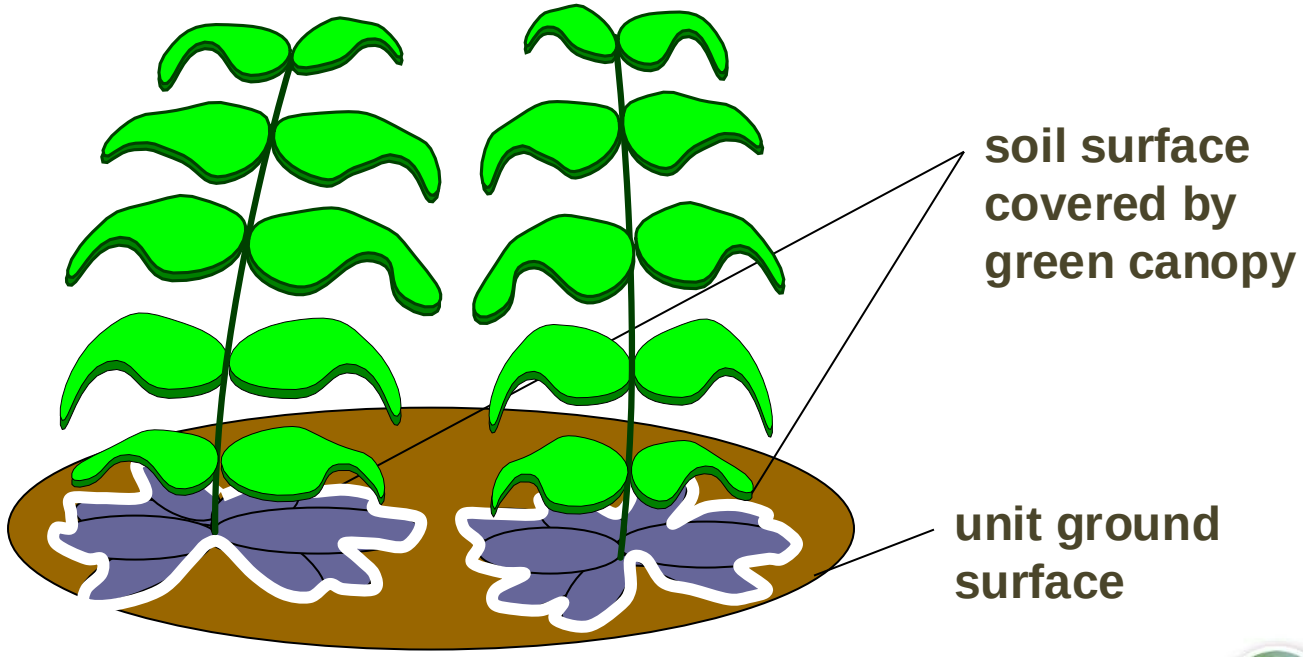
Calculation scheme of AquaCrop



Green canopy cover (CC)

Ranges from 0 (bare soil) to 1 (full canopy cover)

0 % **100 %**



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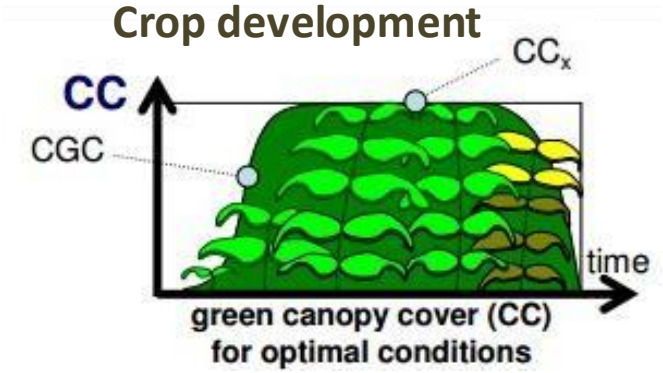
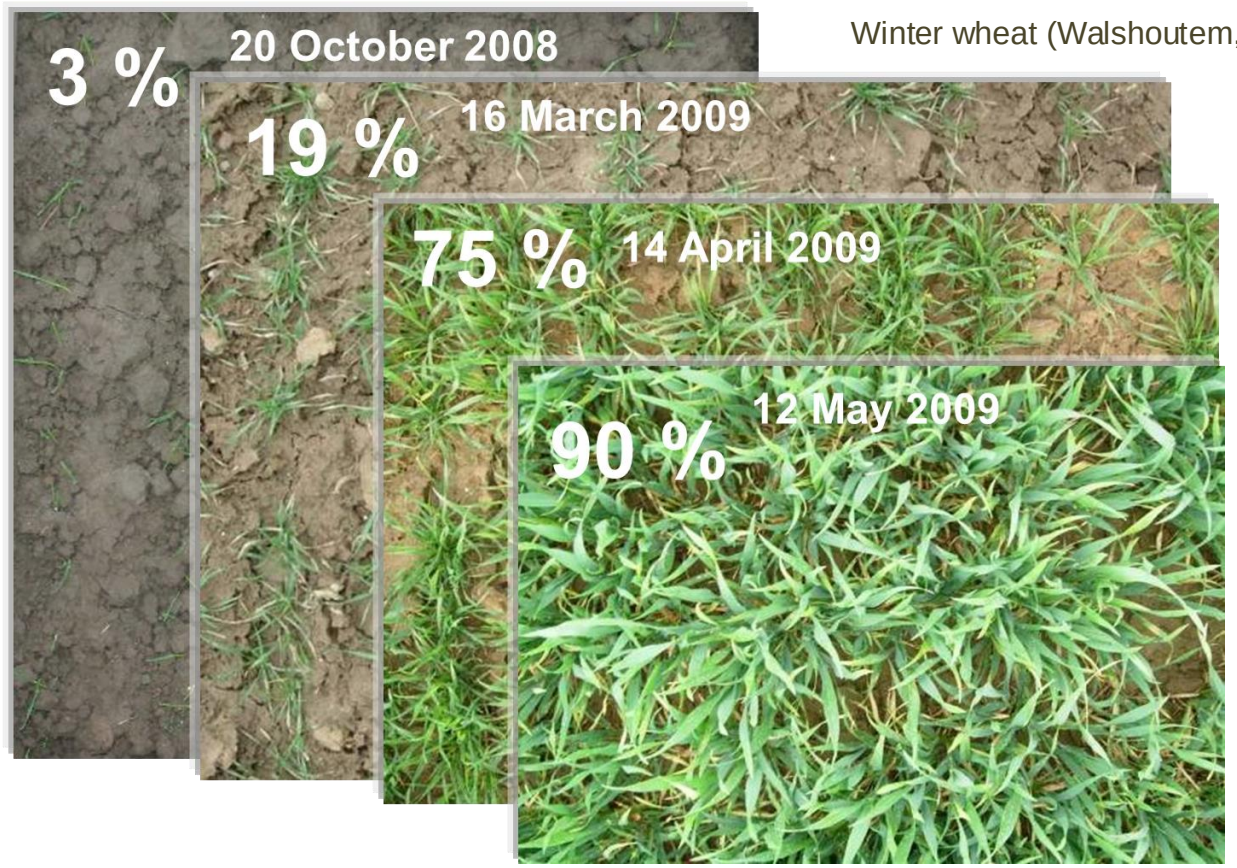
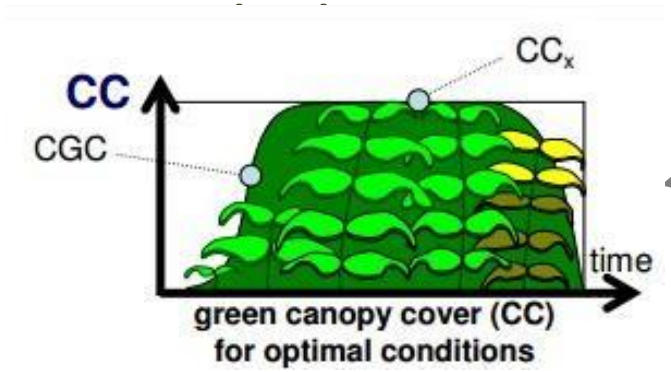


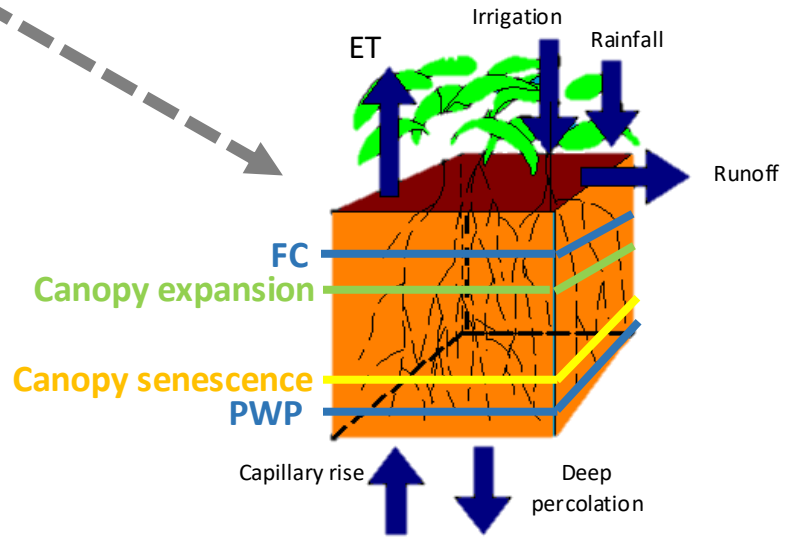
Green canopy cover (CC)



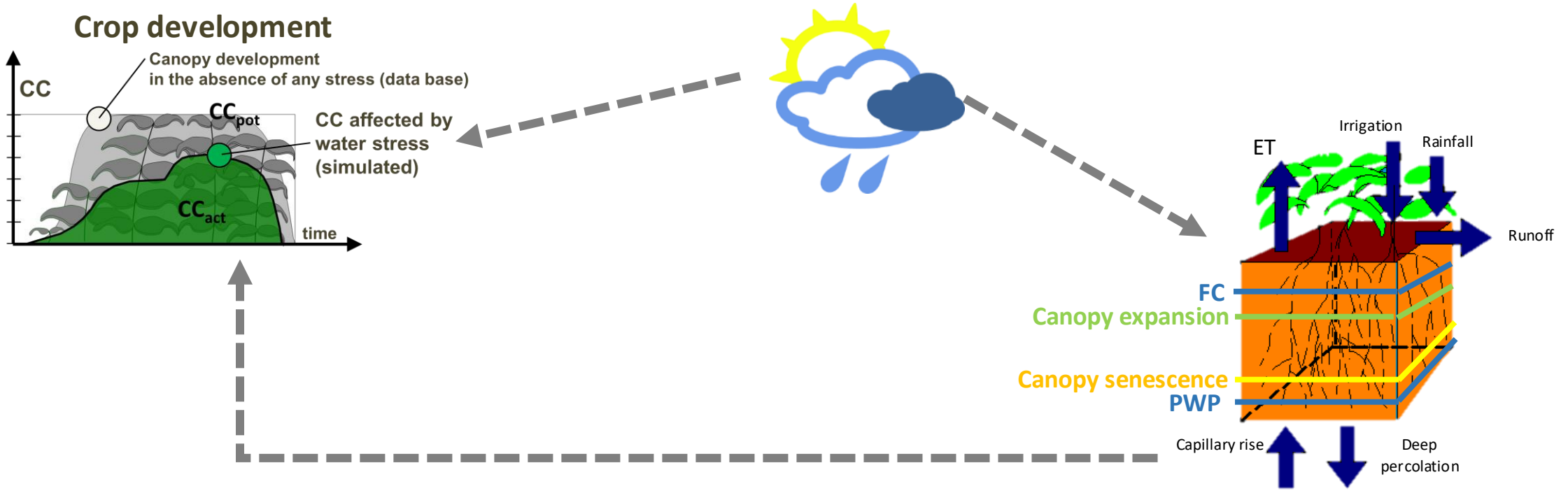
Winter wheat (Walshoutem, Belgium)

Calculation scheme of AquaCrop





Calculation scheme of AquaCrop



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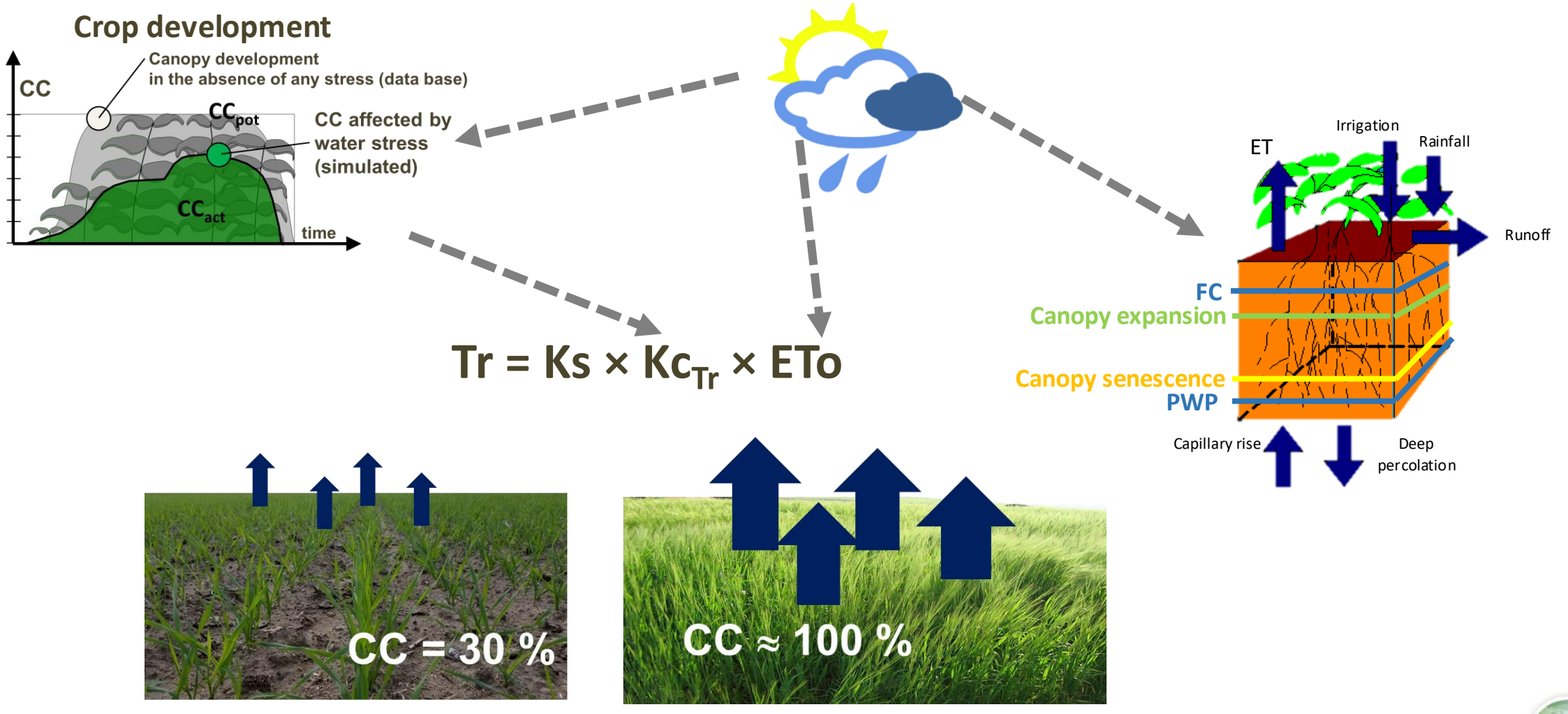

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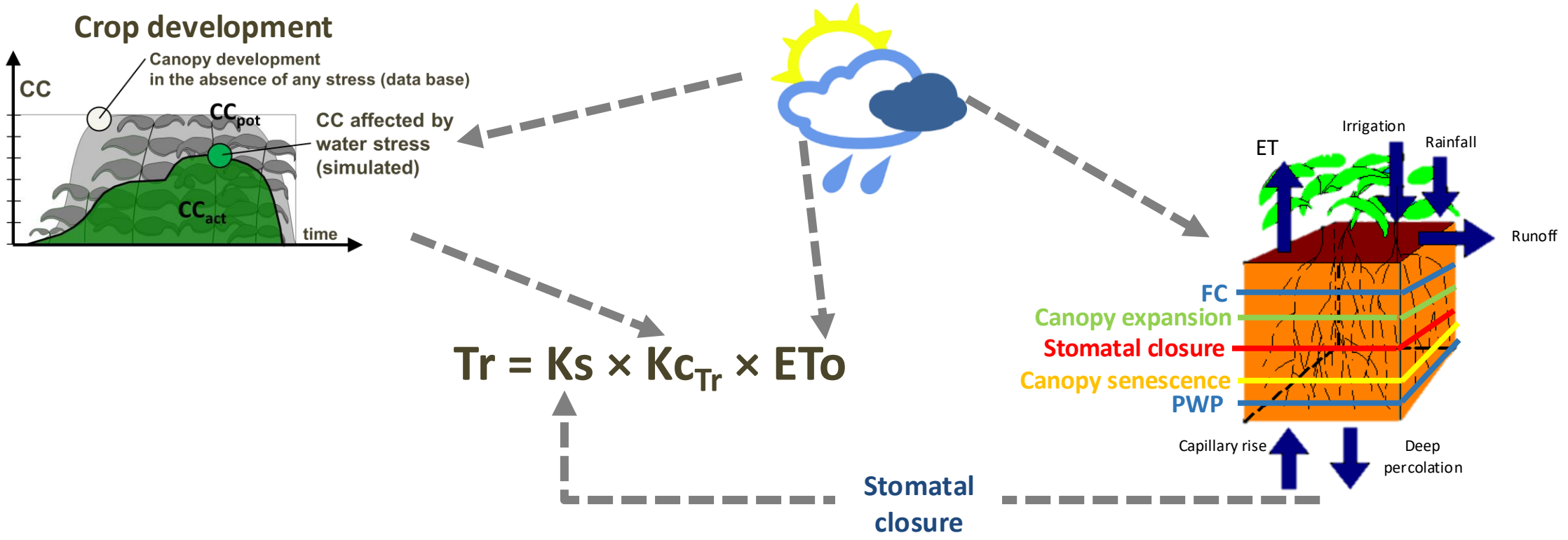

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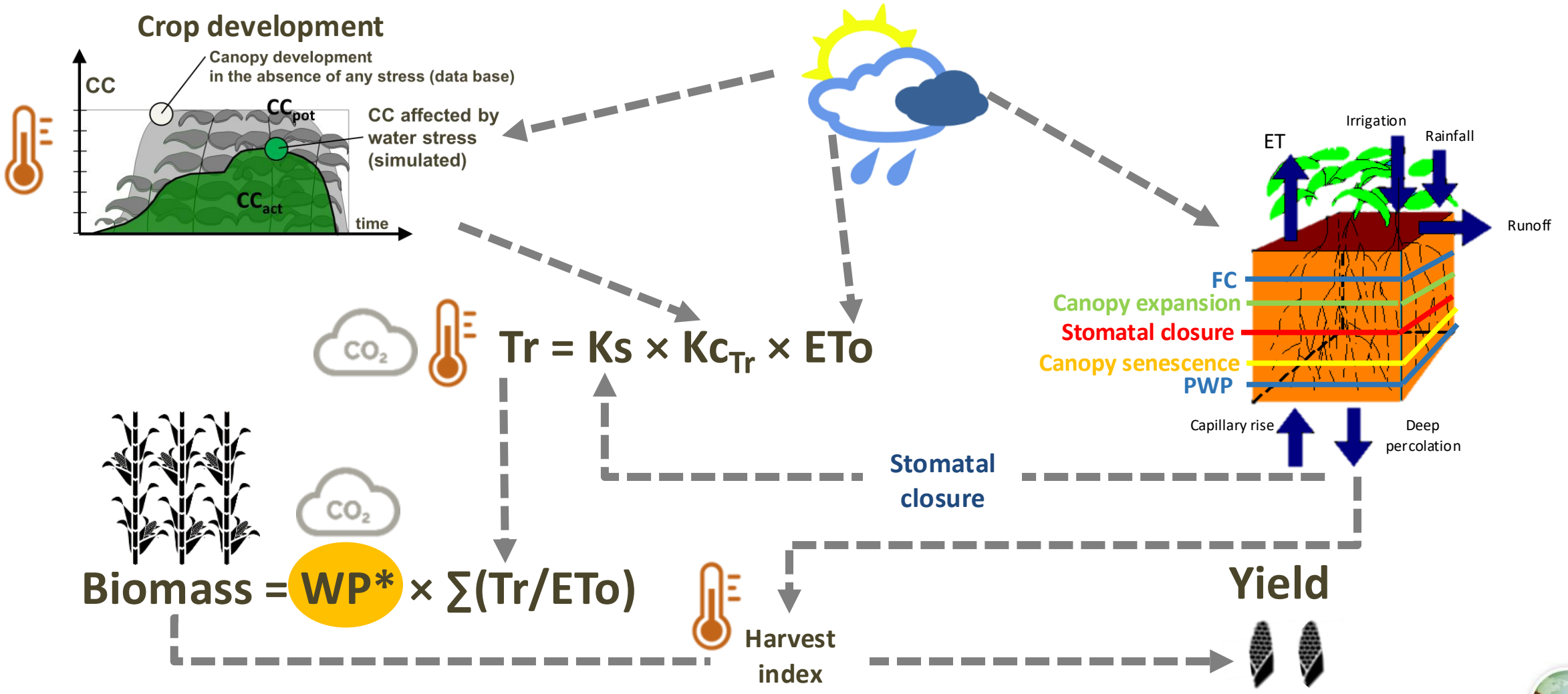


AquaCrop model overview

Yield levels

AQUACROP

No nutrient balance

Need for local calibration

Potential	Attainable	Actual
Genetic limits	Genetic limits	Genetic limits
+	+	+
Defining factors	Defining factors	Defining factors
• CO_2 • Radiation • Temperature	+	+
	Limiting factors	Limiting factors
	• Water • Nutrients	+
		Reducing factors
		• Weeds • ~~Pests~~ • ~~Diseases~~ • Salinity

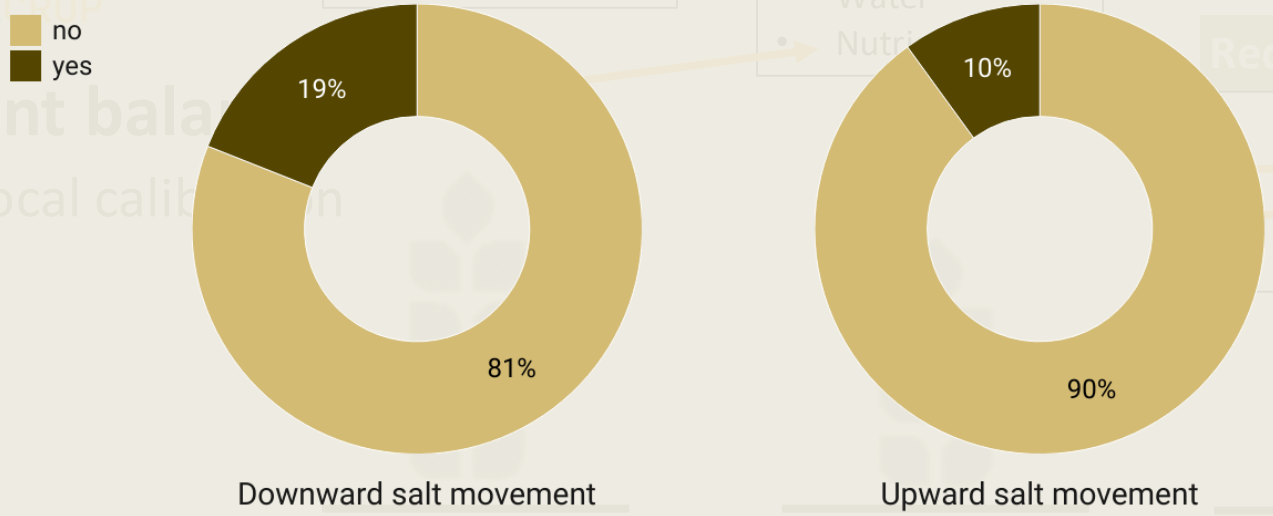
Adapted from: Van Ittersum et al. (2003)

AquaCrop model overview

Yield levels

Potential	Attainable	Actual
Genetic limits	Genetic limits	Genetic limits
+	+	+
Defining factors	Defining factors	Defining factors
• CO_2 • Radiation • Temperature	+	+
	Limiting factors	Limiting factors
	• Water • Nutrients	+
		Reducing factors
		• Weeds • Pests • Diseases • Salinity

Wheat crop models



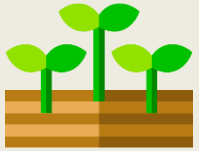
García-Vila et al. *(Submitted)*

Adapted from: Van Ittersum et al. (2003)

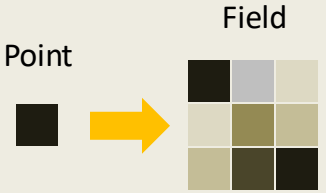
AquaCrop model overview

Other limitations

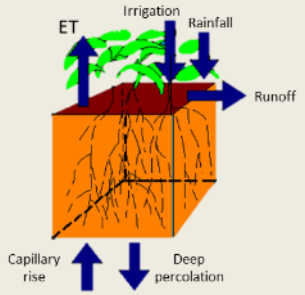
Herbaceous crops



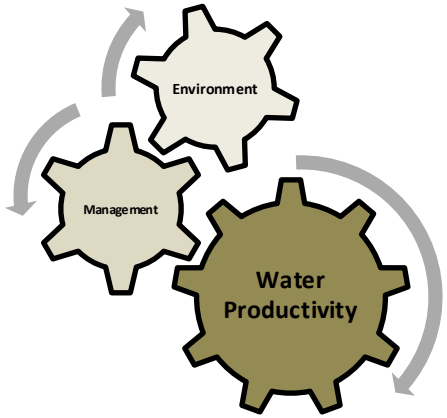
Uniform field



Vertical fluxes



AquaCrop model overview



Practical applications

- Yield gap analysis
- Evaluate impact of different crop and field management practices
- Develop optimal irrigation schedules
- Formulate irrigation strategies under water deficit conditions
- Assess crop responses to environmental change

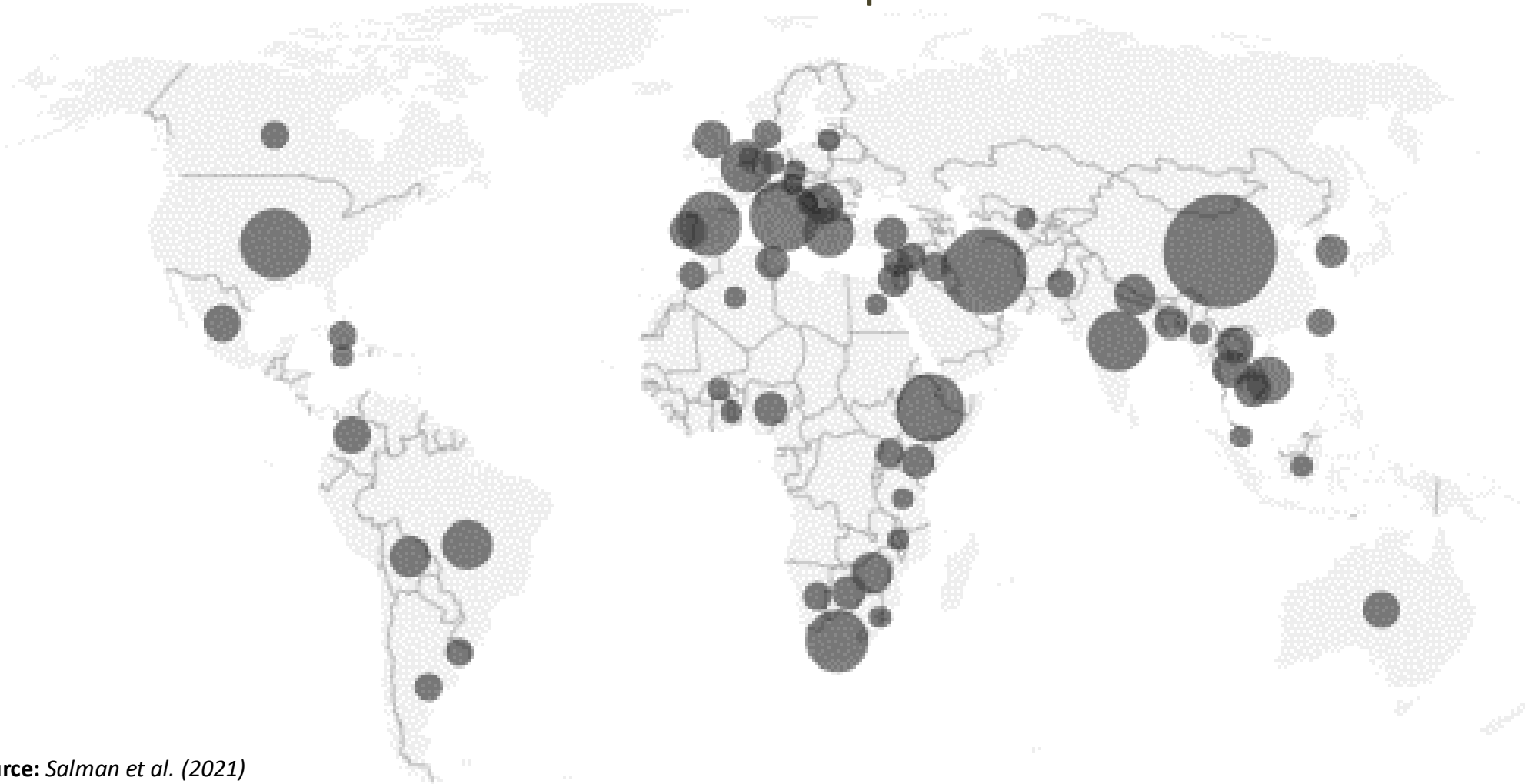
Provide guidelines for farmers

Decision support tool for policy makers

AquaCrop model overview

Number of publications

Model implemented in 63 countries



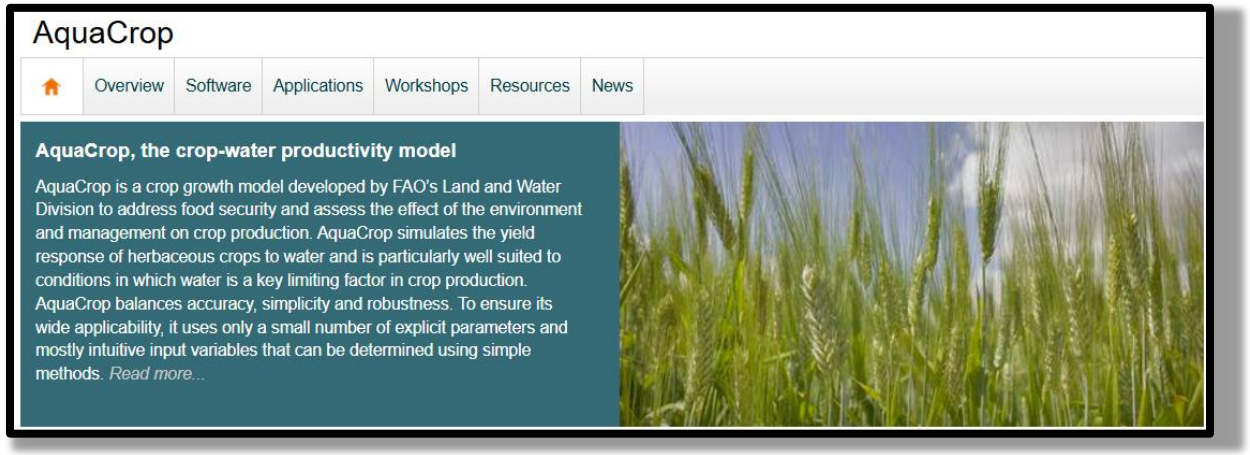
Source: *Salman et al. (2021)*

AquaCrop model overview

References

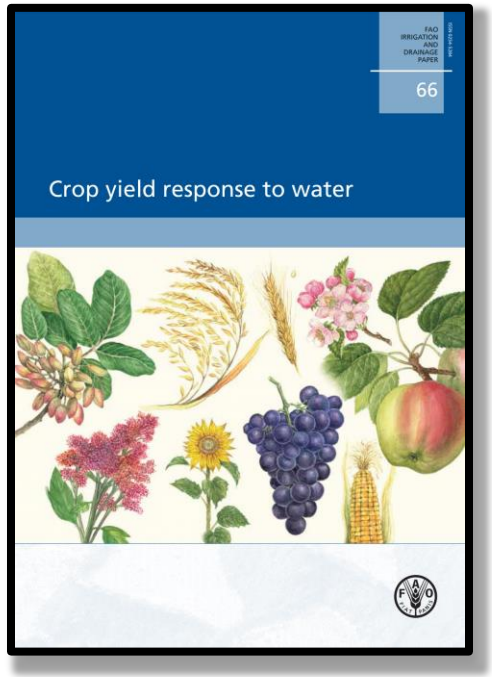
FAO AquaCrop website

https://www.fao.org/aquacrop/en/



FAO Irrigation and Drainage paper Nr. 66

http://www.fao.org/docrep/016/i2800e/i2800e00.htm



Food and Agriculture Organization of the United Nations

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Modelling plant growth with AquaCrop, 26 November 2024

GLOBAL SOIL PARTNERSHIP