The WOFOST model,

its principles, implementation, main parameters and examples of use

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Origin and initial objectives MARS

- 1988 start
- MARS = Monitoring Agriculture with Remote Sensing
  - Leadership: EC-JRC in Ispra, Italy
  - Customers: EC-DG-Agri and Eurostat
  - Developers: JRC and contractors (research institutes)
- *Task:* develop a system to estimate regional crop production for Europe
- *Required information :* independent, unbiased and timely estimates of the production of major European crops
  - per EU country
  - crop-specific
  - early within season
  - cost-effective

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Target information and reference data

Crop **production** estimates = CROP YIELDS * ACREAGE

- Early forecast crop yields
- Precise Crop Area Estimates

Yield estimates in MARS 199ies from

- MARS Action 2 AVHRR, and Action 4 rapid estimates
- **MARS Action 3 meteo, agromet models,**
  - Data types: weather, soil, land use, elevation
  - Data on current year and in historic archive, daily to 10-daily
  - Full spatial coverage over Europe,
  - Resolution: ideal elementary reference is single crop field (crop, soil, weather)

See http://www.marsop.info/marsop3/

MARS Action 3 Agromet models

Goal: quantification of inter-annual yield variability per crop over regions and countries through objective, science-based, reproducible results

Assumptions on yield of annual field crops:

- Weather is main driving factor
- A priori choice for semi-deterministic crop model to integrate effects of many meteo data
- Thus many meteo data are concentrated into few simulated yield data
- Output of crop model is used as predictor of regional crop yield in a statistical model

(Note: a stand-alone statistical agromet model cannot deal with multitude of meteo-data)

Agromet model CGMS : three levels

The MARS Action 3 resulted in
the Crop Growth Monitoring System (CGMS) combining

- Level 1 Weather monitoring
- Level 2 Crop monitoring by simulation (WOFOST)
- Level 3 Yield forecast by regression

Note: Vegetation monitoring based on
Low Res NOAA-AVHRR and SPOT Vegetation
are separate processing lines

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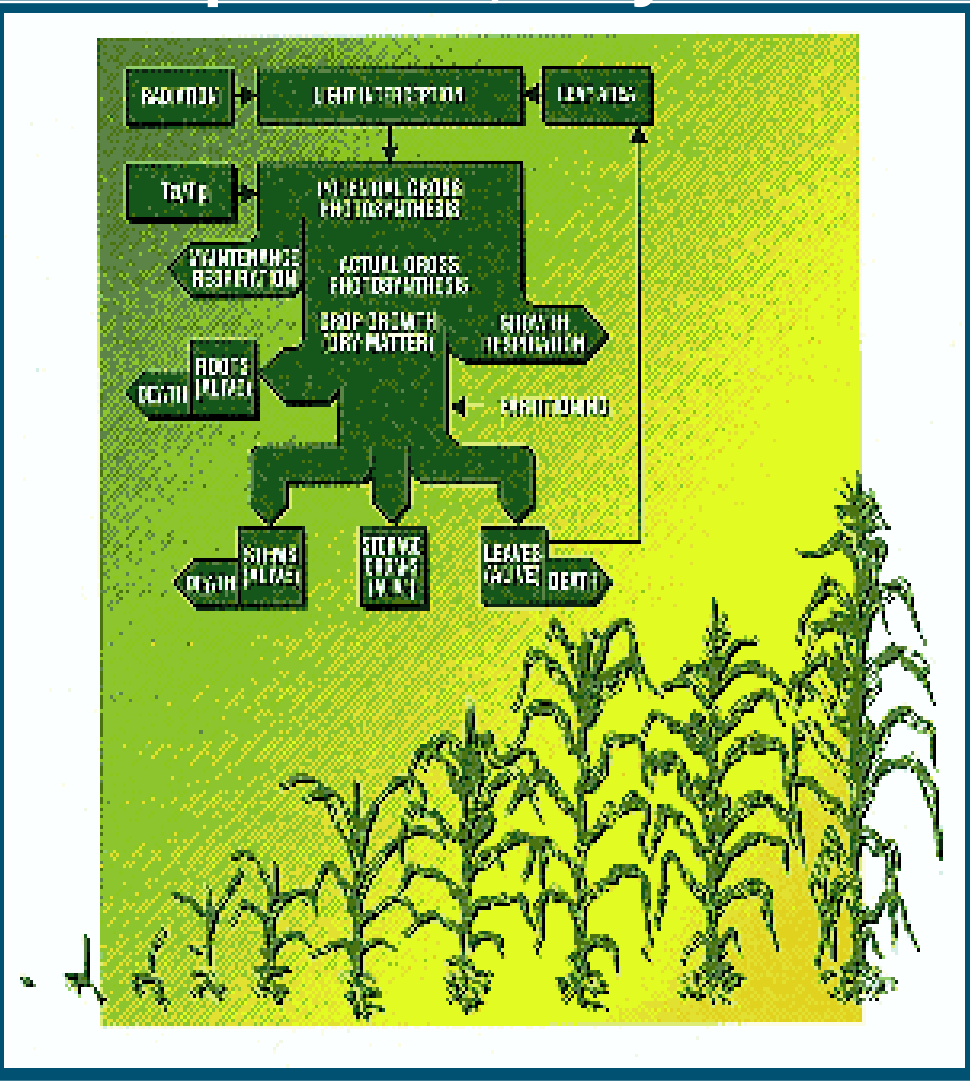
The CGMS Crop Model, why WOFOST ?



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Choice of model for regional yield forecasting

Original aim of crop models

- Integrate knowledge on plant growth processes
- Test hypothesis by mathematical reproduction of experiments in laboratory or trial fields
- Explain crop responses under a range of conditions (ecological, management), covered by experiments
- Explore crop responses under a range of conditions not yet covered by experiments

- Detailed multi-parameter complex models may be over-sensitive to variation in input
- Simple summary models may be insensitive to variation in input

- For practical applications a balanced level of complexity and sensitivity must be found, while taking account of data availability.

Crop modeling approach according to De Wit

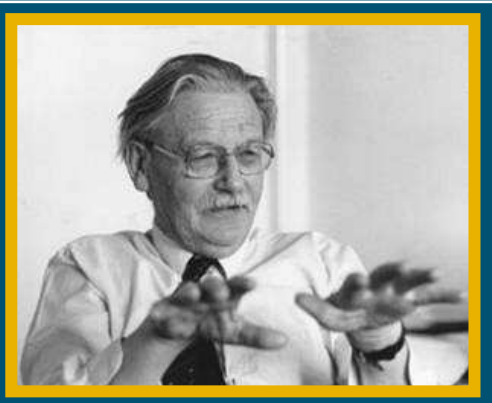
Original idea: Photosynthesis of leaf canopies (de Wit 1965)

- Biophysical crop system, driven by light interception and photosynthesis
- Dynamic
- Hierarchical
- State-variable based
- Explanatory
- Deterministic
- Generic, universal

Crop modelling approach according to De Wit

- System is a simplified description of reality: a homogeneous crop field, with defined thematic boundaries, internal characteristics and external driving variables
- Dynamic: Rates of change per unit time as opposed to static. Integration over time.
- Hierarchical
  - Within a system: Cells – organs – plants- crop
  - Sequence in system complexity defined by a succession of theoretical production situations: potential, water-limited, nutrient-limited,
- State-variable based: Starting from gives initial state, each state is updated each time step, where State = previous state + rate of change. Most basic crop states are expressed in dry weight of living biomass and crop development stage (crop age)
- Explanatory: explicit quantitative description of bio-physicaL processes leading to change in system state, by means of mathematical equations
- Deterministic: a given crop responds according to the rules, defined in the model (apparent absence of uncertainty)
- The most basic processes are generic and universally valid for all crops and all crop varieties (“ It is green and it grows”)..

Pedigree of models of the 'School of de Wit'



1965
1970
1975
1980
1985
1990
1995
2000
2005

Photosynthesis of leaf canopies (de Wit 1965)

ELCROS (de Wit et al. 1970)

MICROWEATHER (Goudriaan 1977)

ARID CROP (van Keulen 1975)

ARID CROP (SAHEL) (van Keulen et al. 1986)

BACROS (de Wit et al. 1978)

PHOTON (de Wit et al. 1978)

PAPRAN (Seligman & van Keulen 1981)

SUCROS (van Keulen et al. 1982)

SWHEAT (van Keulen & Seligman 1987)

SUCROS87 (van Laar et al. 1992)

SUCROS1 (Goudriaan & van Laar 1994)

SUCROS2 (van Laar et al. 1997)

WOFOST (van Diepen et al. 1988) (van Keulen & Wolf 1986)

WOFOST 7.0 (Boogaard et al. 1998)

MACROS (Penning de Vries et al. 1989)

INTERCOM (Kropff & van Laar 1993)

ORYZA (Kropff et al. 1995)

ORYZA2000 (Bouman et al. 2001)

GECROS (Yin, van Laar 2005)

Adapted from Bouman et al. 1996.

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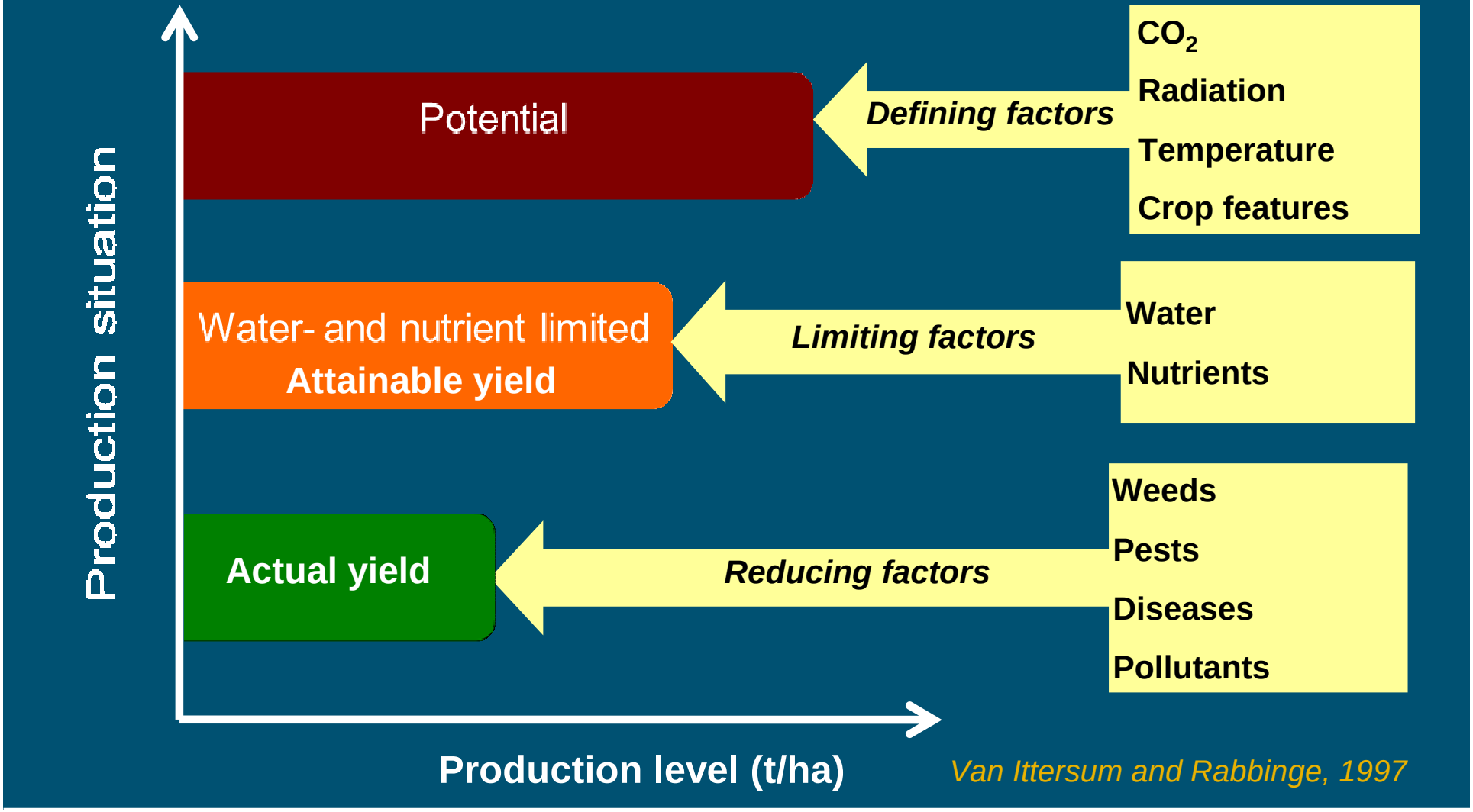
The model crop: it is green and it grows

- Differences in crop growth processes between crops are due to different model parameter values.
- A cereal crop is the basic reference for an annual field crop in the crop model.
- Root crops, legumes, vegetables and grasses are forced into the basic cereal model.

In many crop models: a crop is a tube conveying water from the soil to the atmosphere

Production ecological principles of yield levels



Van Ittersum and Rabbinge, 1997

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Definitions Production Situations

- Potential yield – yield potential:
  - the yield of crop (cultivar/hybrid) when grown under defined conditions (CO2, T, radiation) without growth limitations from water, nutrients, pests or diseases
- Water-limited/nutrient-limited yield:
  - the yield of a crop (cultivar/hybrid) when grown with water limitation or with one or more nutrient deficiencies as the primary growth limiting factors
- Actual yield:
  - the measured yield from a field or farm, or the estimated average yield for a region or nation as reported in national and international databases.

How estimated:

- through a model, experiments, best practice or census data

WOrld FOod Studies crop simulation model,

of potential and water-limited production situations

since 1986

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SUCROS-family models (including WOFOST) modeling scheme: state-driver-rate

(Simple and Universal CROp growth Simulator)

process

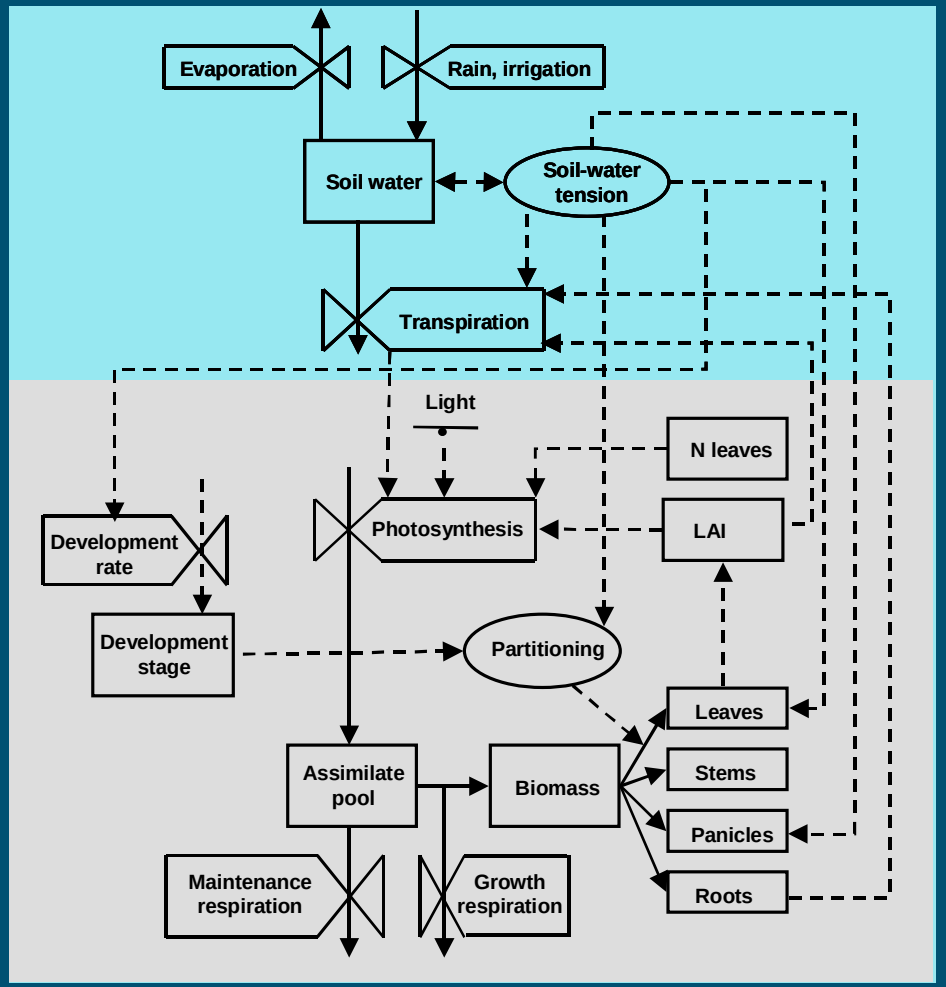
State

rate

driver

Soil & water submodel

Plant growth submodel



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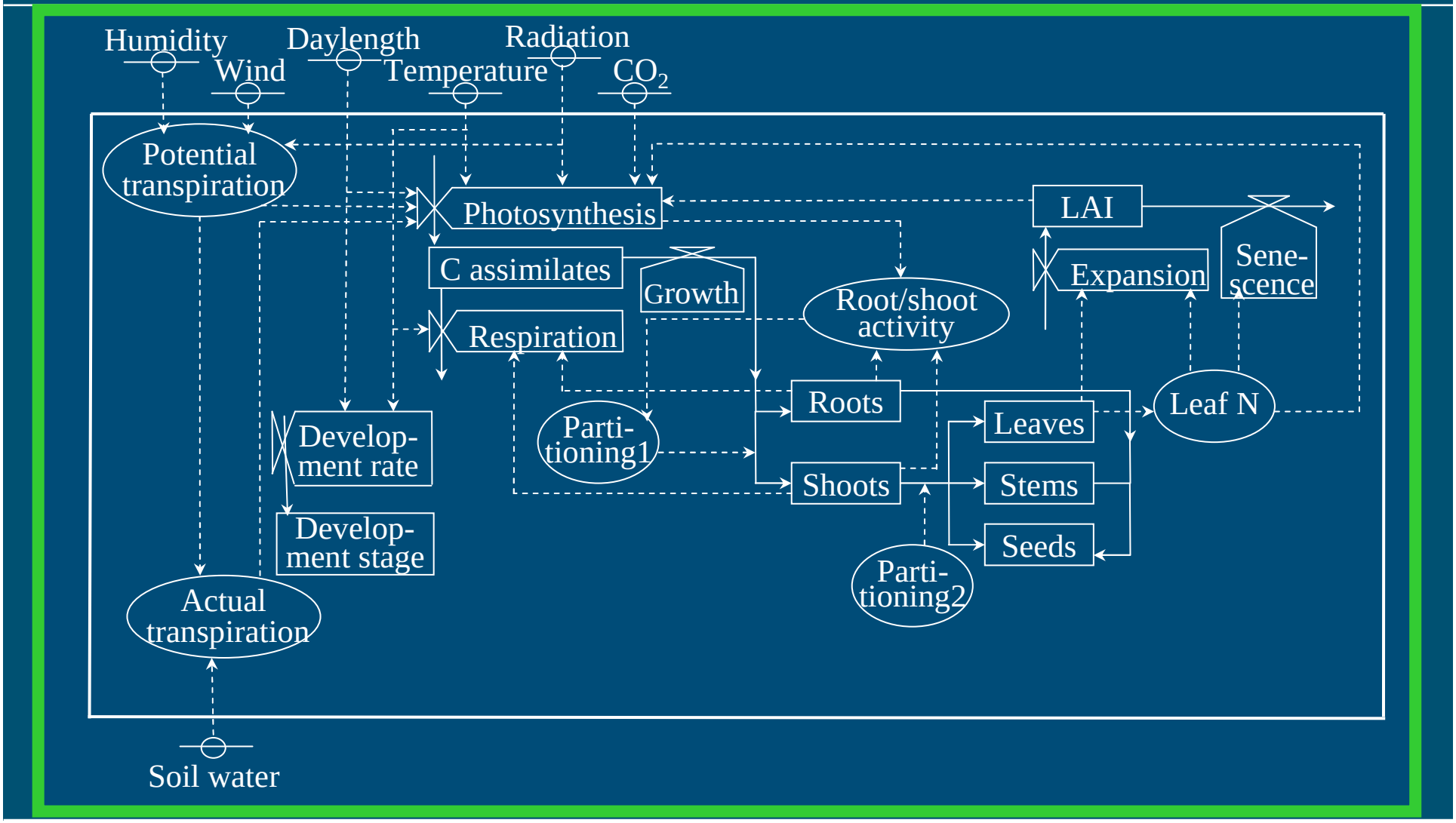
SUCROS (WOFOST)-modeling scheme (drivers, processes, state, rate)



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Conclusion

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