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LETTERS
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nature climate change

Adaptation of US maize to temperature variations

Ethan E. Butler* and Peter Huybers

The impacts of climate change on water resources and agriculture in China

Shilong Piao[1], Philippe Ciais[2], Yao Huang[3], Zehao Shen[1], Shushi Peng[1], Junsheng Li[4], Liping Zhou[1], Hongyan Liu[1], Yuecun Ma[1], Yihui Ding[5], Pierre Friedlingstein[2,6], Chunzhen Liu[7], Kun Tan[1], Yongqiang Yu[3], Tianyi Zhang[3] & Jingyun Fang[1]

LETTER

doi:10.103

Closing yield gaps through nutrient and water management

Nathaniel D. Mueller[1], James S. Gerber[1], Matt Johnston[1], Deepak K. Ray[1], Navin Ramankutty[2] & Jonathan A. Foley[1]

nature climate change
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Ground water and climate change

Richard G. Taylor *et al.**

SOILS—THE FINAL FRONTIER
VIEWPOINT

Soil Carbon Sequestration Impacts on Global Climate Change and Food Security

SPECIAL SECT

Nonlinear temperature effects indicate severe damages to U.S. crop yields under climate change

Wolfram Schlenker[a,1] and Michael J. Roberts[b]

CLIMATE CHANGE

Losing Arable Land, China Faces Stark Choice: Adapt or Go Hungry

To ensure food security, China is racing to develop new cultivars of staple grains that thrive in a warmer world

Scientific issues
-why we focus on crop dynamics (also managed land)?

- Food security responses to environmental changes (climate variability, extreme events, warmer temperature, drought, LUC, water-resource deficit, …)
- Carbon balance (carbon flux of atmosphere-terrestrial, soil carbon-crop feedback, effects of phenology on carbon seasonal dynamics, …)
- Climate feedback (regional, heat and water flux changes, etc)
- Others (nutrition leaching and water pollution, …)

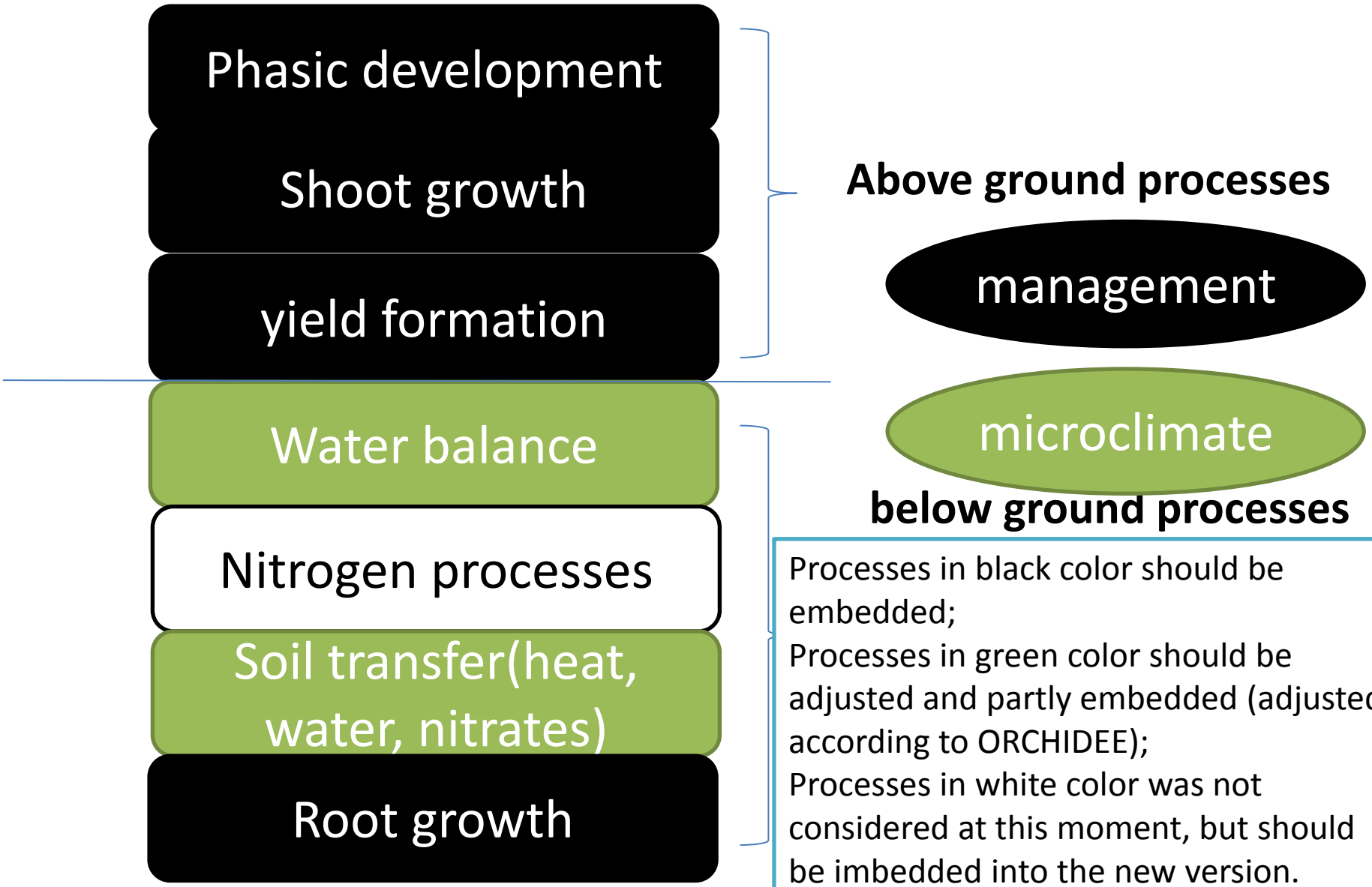
Problems in modeling crop dynamics in standard ORCHIDEE

1. LAI (more realistic-STICS)
2. Photosynthesis (?)
3. Allocation, senescence, and harvest
4. Root density profile (dynamic and true-STICS)
5. soil moisture stress (adjust many processes)
6. vegetation height (more realistic-STICS)
7. Nitrogen stress (now we do not consider, but maybe represented in a new version-based on OCN)

How can we do?
-model development-ORCHIDEE-STICS

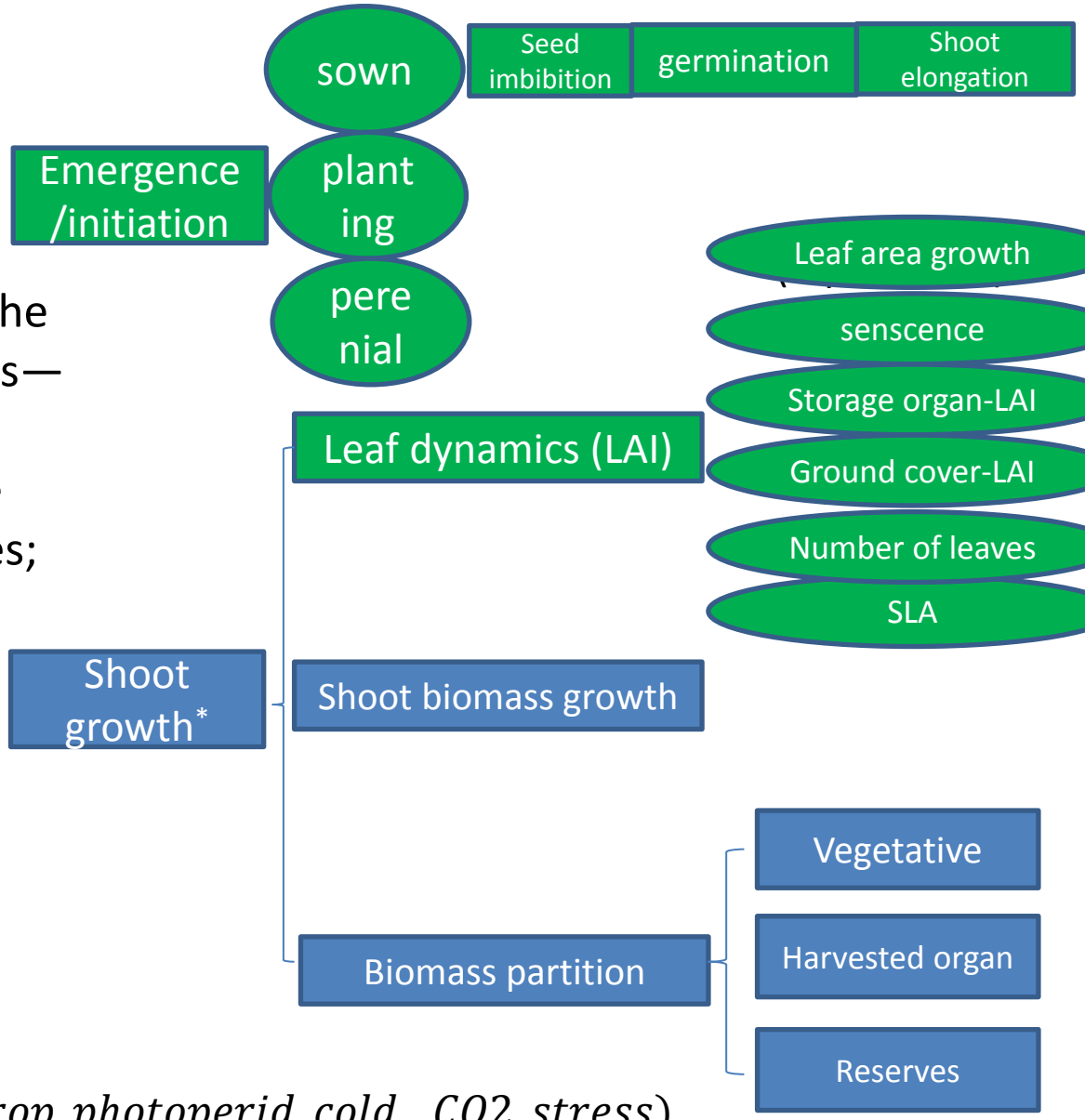
- What do we focus on first?
  - Phenological process(LAI curve-time and magnitude)
  - biomass allocation (dynamics, relating to crop yield, SOC, water and nutrition process and its feedbacks)
  - turnover (Root, litterfall, related to soil carbon/nitrogen dynamics)

- Main modules/processes in STICS



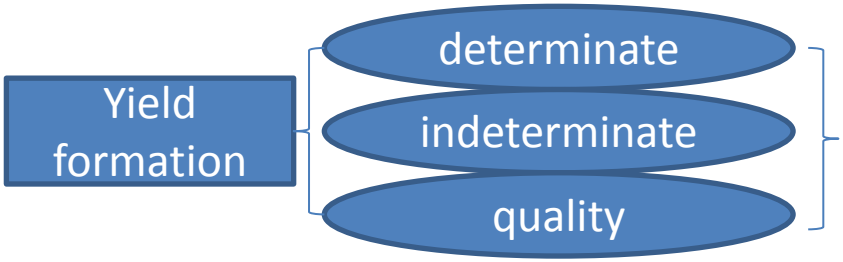
Phenological processes and biomass dynamics

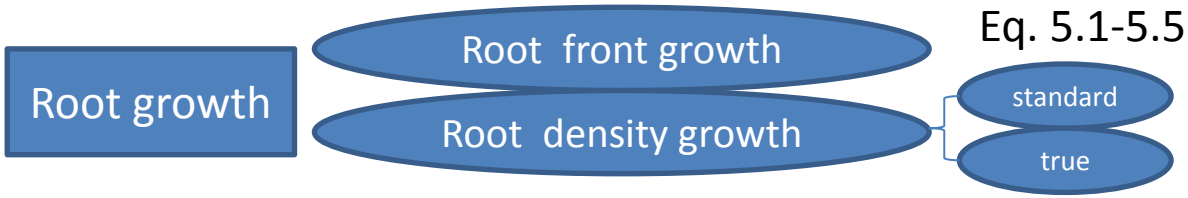
Green color: representing the main phenological processes—mainly focus on the LAI;
Blue color: representing the biomass allocation processes;



$* \; shoot\ growth = f(Tcrop, photoperid, cold, , CO2, stress)$

Continue：





Eq. 5.1-5.5

At the end of crop cycle, the roots senesce and enter the mineralization processes as crop residue-soil carbon cycle

Seed imbibition

- Seed imbibition (length, days) = f(species-dependent component, T_soil, T_germination base temperature, T_maxthreshold) (eq. 2.1);
- Min_threshold =<Seed imbibition <= Max_threshold

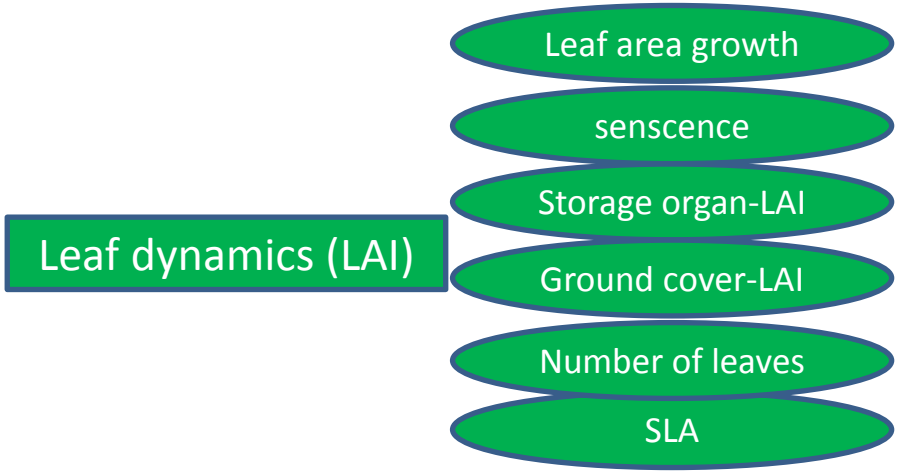
germination

- Germination start if GDD_seed bed >= threshold;
- GDD_seed bed = f(Tsoil, T_germination_base, Soil moisture_seed bed);
- Soil moisture_seed bed = f(actual water content, wilting point, field capacity in seed bed, species-specific parameter);

Shoot elongation/emergence

- Density = f(frost, crust stress);
- Elongation = f(Tsoil, T_germination base temperature, water status, crust stress, species-specific parameters)

Focus on shoot growth-more detail



= f(initial LAI growth rate, Tcrop, density, water and nitrogen stress)

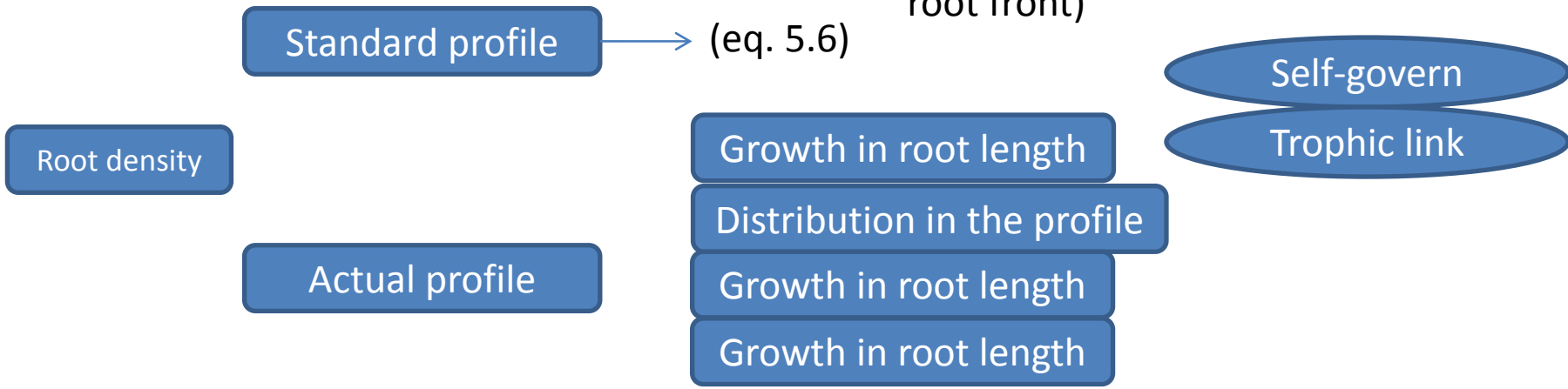
Root growth (cont.)

- Root front growth (begins at depth of the root front, stops when it reaches the depth of soil or an obstacle that can be physical or chemical, or when the phenological stopping stage has been reached)
- Front_growth_rate = f(first_front_growth_rate, water and bulk density stress)
  - First_front_growth_rate = f(Tcrop or Tsoil) (eq. 5.2, 5.3);
  - Water and bulk density stress = f(soil dryness, water logging, bulk density);

Root growth (cont.)

- Root density (standard profile; actual profile):

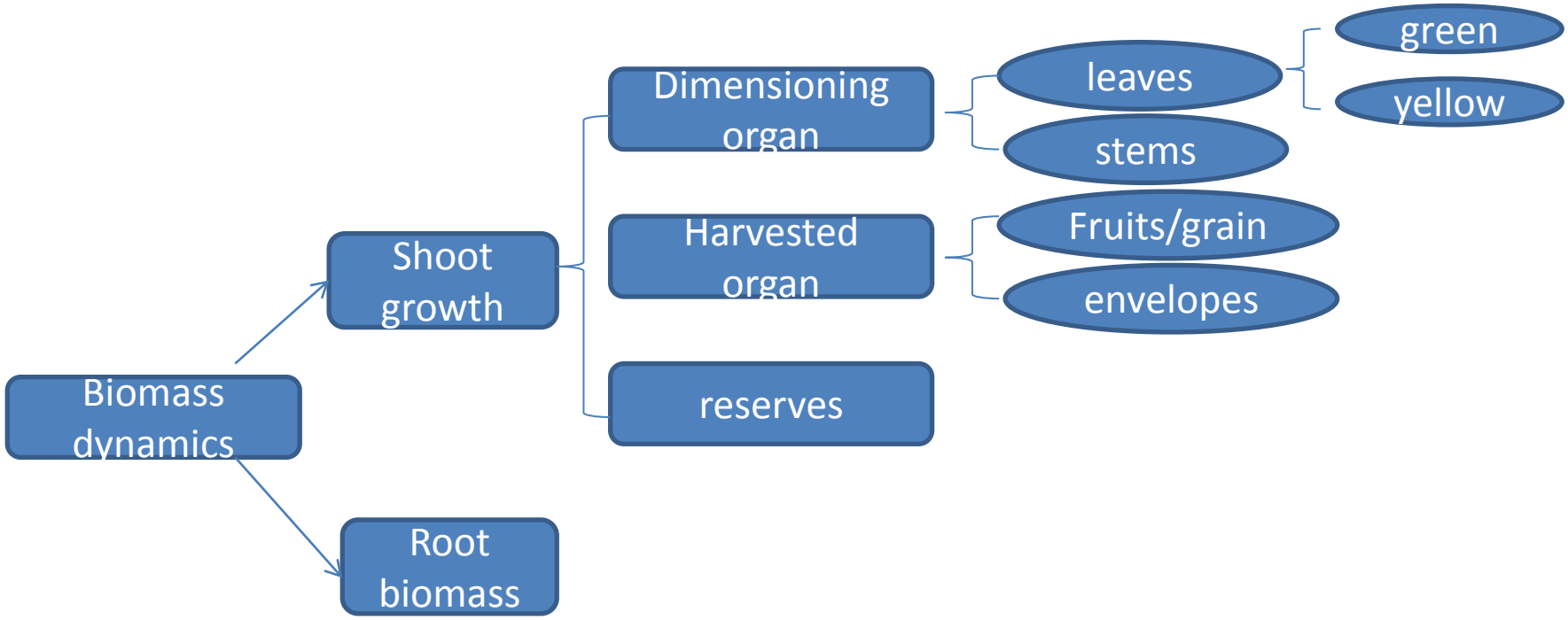
Self_goven=f(initial root length growth rate, Tcrop, plant density, water logging stress, growth at the root front)



Standard profile may lead to some problems: 1) in the tilled zone, root density is not always optimal; 2) the soil constraints are not negligible.

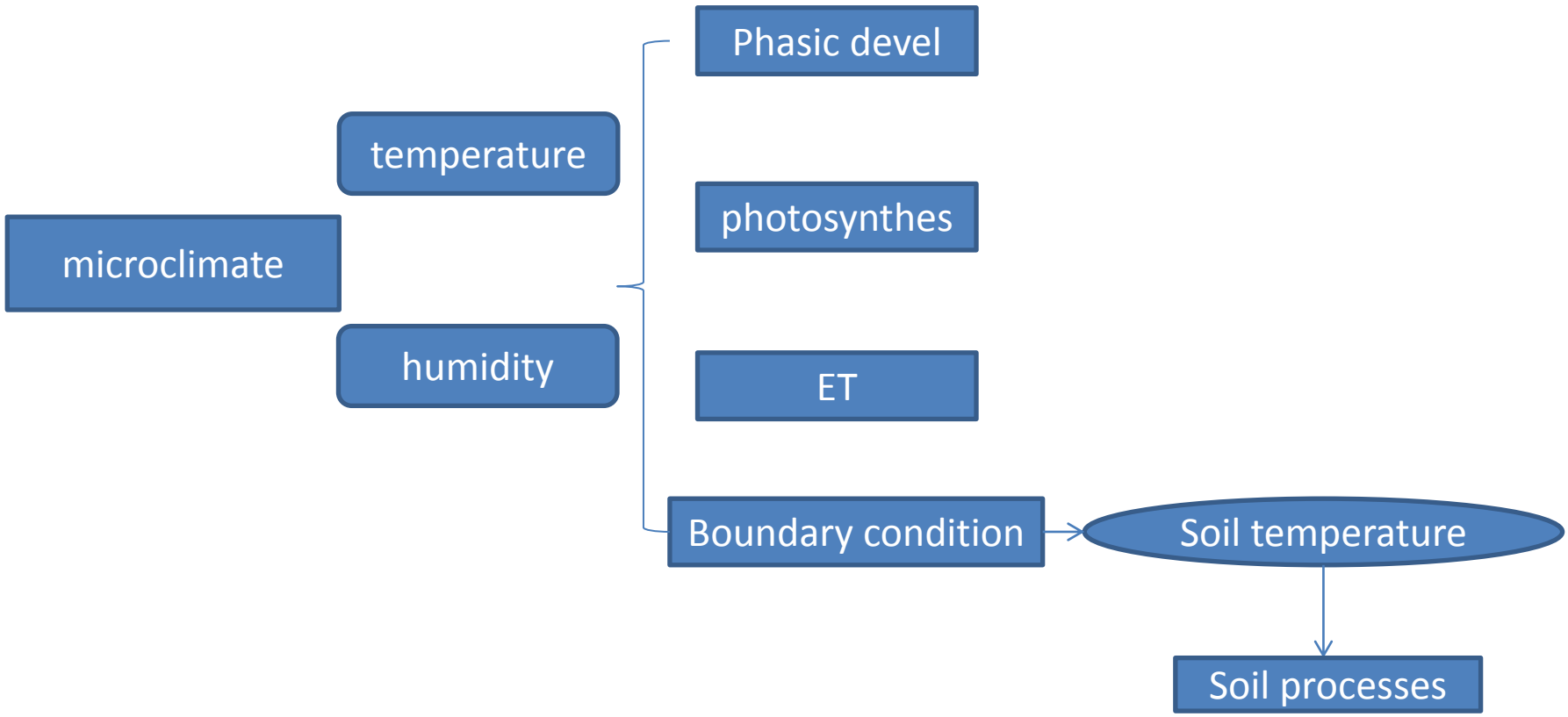
For sown crops, density profile was only considered since emergence.

Focus on the biomass dynamics



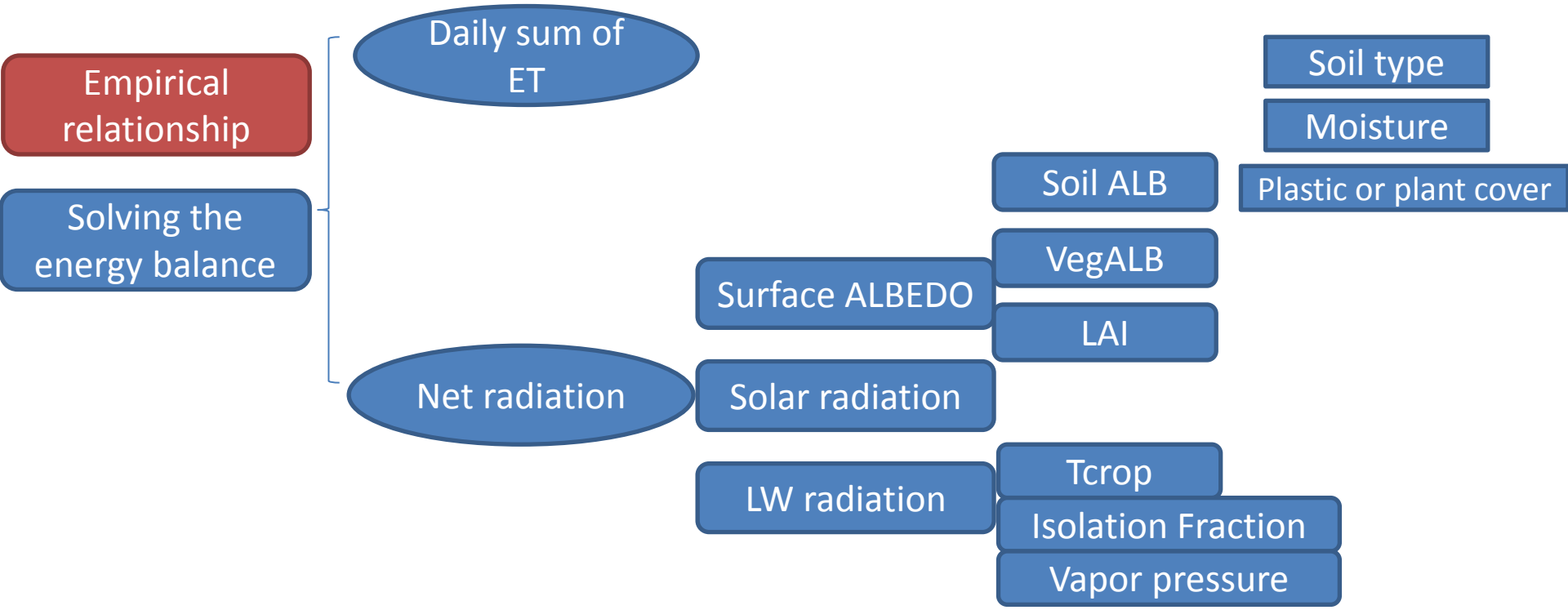
Equations are all listed in the book.

Microclimate



Microclimate (cont.)

- Tcrop = f(Tcrop_min, Tcrop_max);
- Two methods for calculating the crop temperature:



Next steps

- Go deep into the source codes of both models (some processes);
- Compare the corresponding processes in ORCHIDEE and STICS and find the differences;
- I will modify the processes in ORCHIDEE according to that in STICS.

- Thank you!

- Comments and suggestions!

Keep in mind

- 1. first, leaf growth and allocation (water limitation);
- 2. Transfering function between Tcrop and Tair and/or Tsoil;
- 3. find the routines relating to the two processes (phenological processes and biomass allocation—considering stress limitation) in the two models; how to build the linkage (transferring parameters) between the routines;
- 4. what are the effects of brown LAI (not addressed enough before, water balabce, etc);
- 5. first subroutines for addressing above processes.