DOFOCO – Do Forests Cool the Earth?

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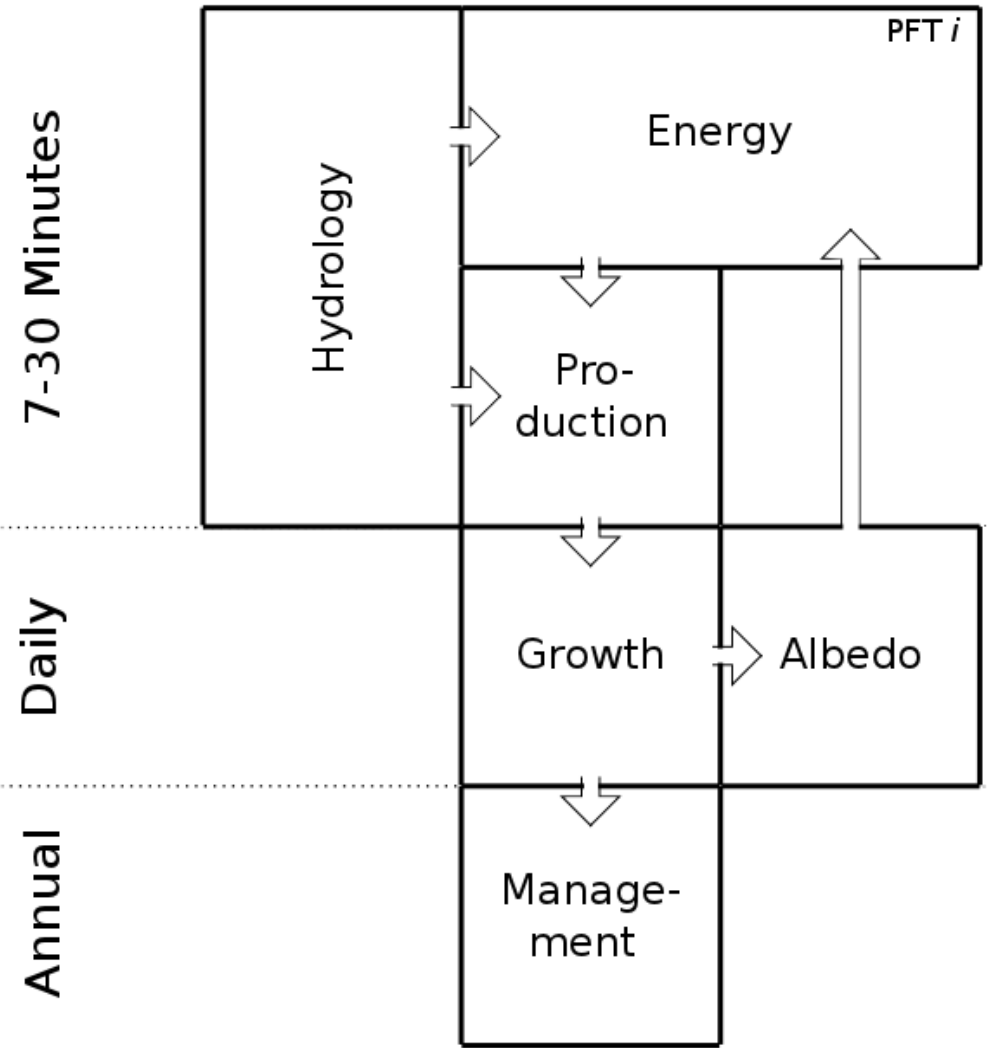(a) Could tree species selection contribute to mitigating the effects of summer heatwaves?

(b) Could forest management contribute to mitigating climate change?
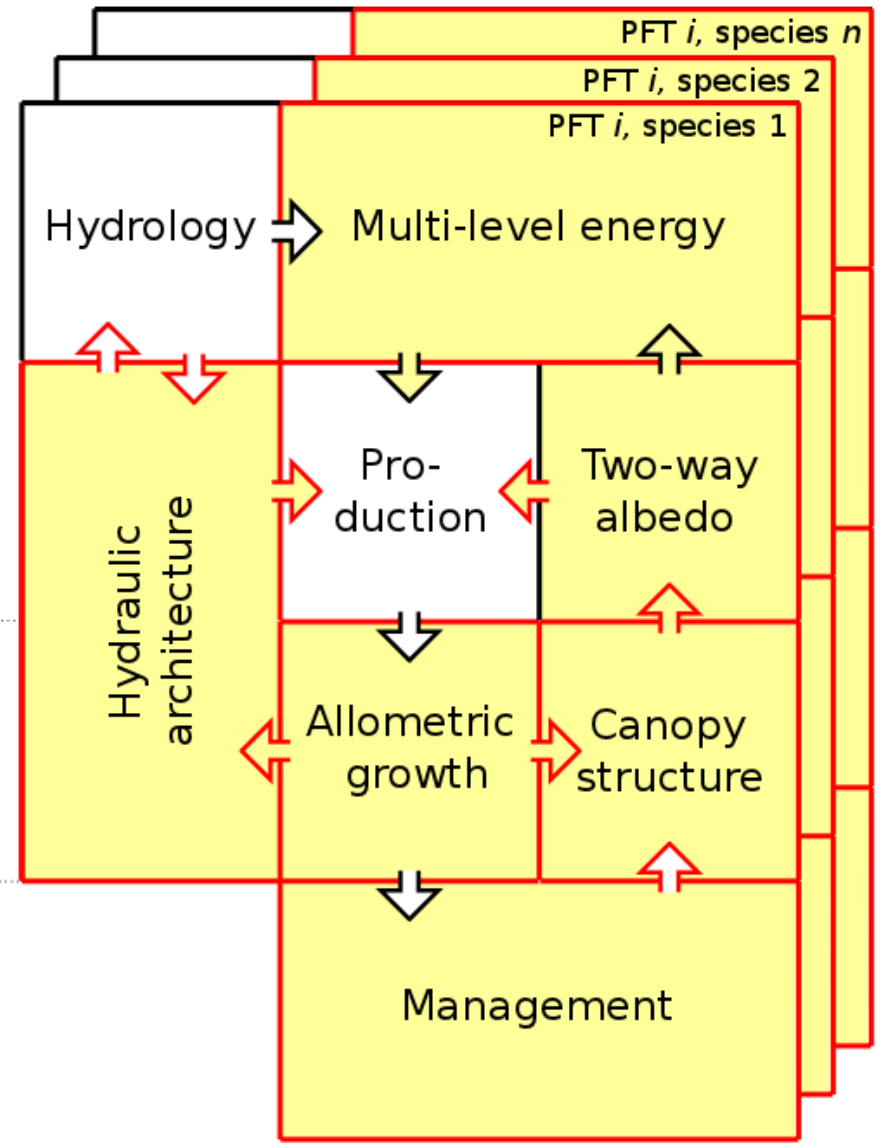

(c) Can we propose a forest management portfolio for minimizing climate effect while sustaining ecosystem services?

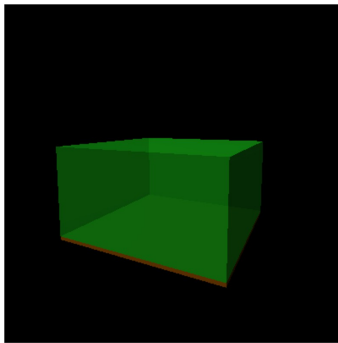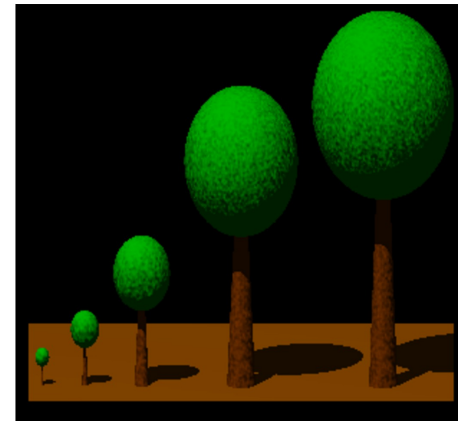**DOFOCO developments**

TRUNK r1170

DOFOCO r1470

Prescribe

Trunk r1170

-Unscructured biomass pools

-Number of individuals is diagnostic

DOFOCO r1470

$h_1\ h_2\ h_3\quad h_4\qquad h_5$

-Number of indivuals determines biomass

-Create allometric saplings in ncirc different
  height/circumference classes
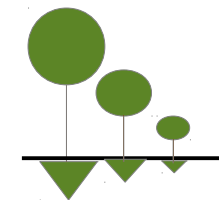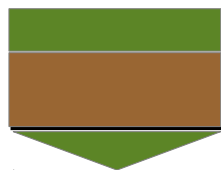
ORCHIDEE DOFOCO stomate_growth.f90

TRUNK v1170

DOFOCO v1470

Within stand competition

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Deleuze and Dhote
Valid for even-aged stands

Allocation

Concept

Stand model

Hybrid stand-tree model

ORCHIDEE DOFOCO stomate_growth.f90

	TRUNK v1170		DOFOCO v1470	
	Stand-level	Tree-level	Stand-level	Tree-level
(a) GPP, Ra, NPP	*		*	
(b) Competition rule (FM)		*		*
(c) Allocation	*			*
(d) Reserves	*		*	
(e) Turnover	*		*	
(f) Mass balance	*		*	*

ORCHIDEE DOFOCO sapiens_lcchange.f90/sapiens_forestry.f90

TRUNK v1170

DOFOCO v1470

Before a stand replacing disturbance
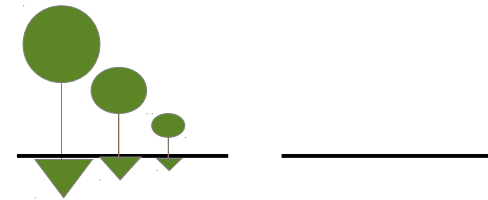
After a stand replacing disturbance

Variables involved

biomass, litter, soil carbon, veget_max

biomass, litter, soil carbon veget_max, soil water

Forest Management

Trunk r1170

-- FM 0: No changes

-- FM 1: Occasionally clearcut, self-thinning

-- FM 2: High stand, thinning and clearcut

-- FM 3: High stand, more thinning

-- FM 4: Coppicing based on age

-- Converts biomass to a continuous
   distribution of individual trees

-- Removes biomass and prescribes
   when needed

DOFOCO r1470

-- FM 1: No intervention

-- FM 2: High stand, thinning and clearcut

-- FM 3: Coppicing based on trunk diameter

-- FM 4: Coppicing based on age (SRC)

-- Uses the same circumference classes as
   elsewhere in the code (ncirc model trees)
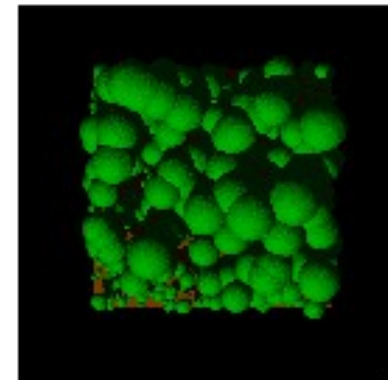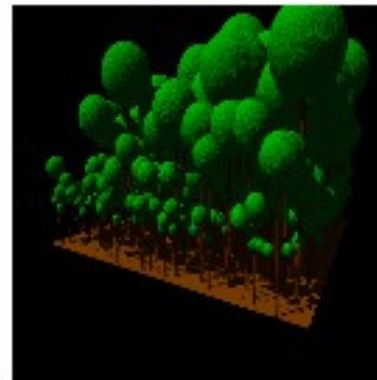
-- Only decides which trees need to be killed
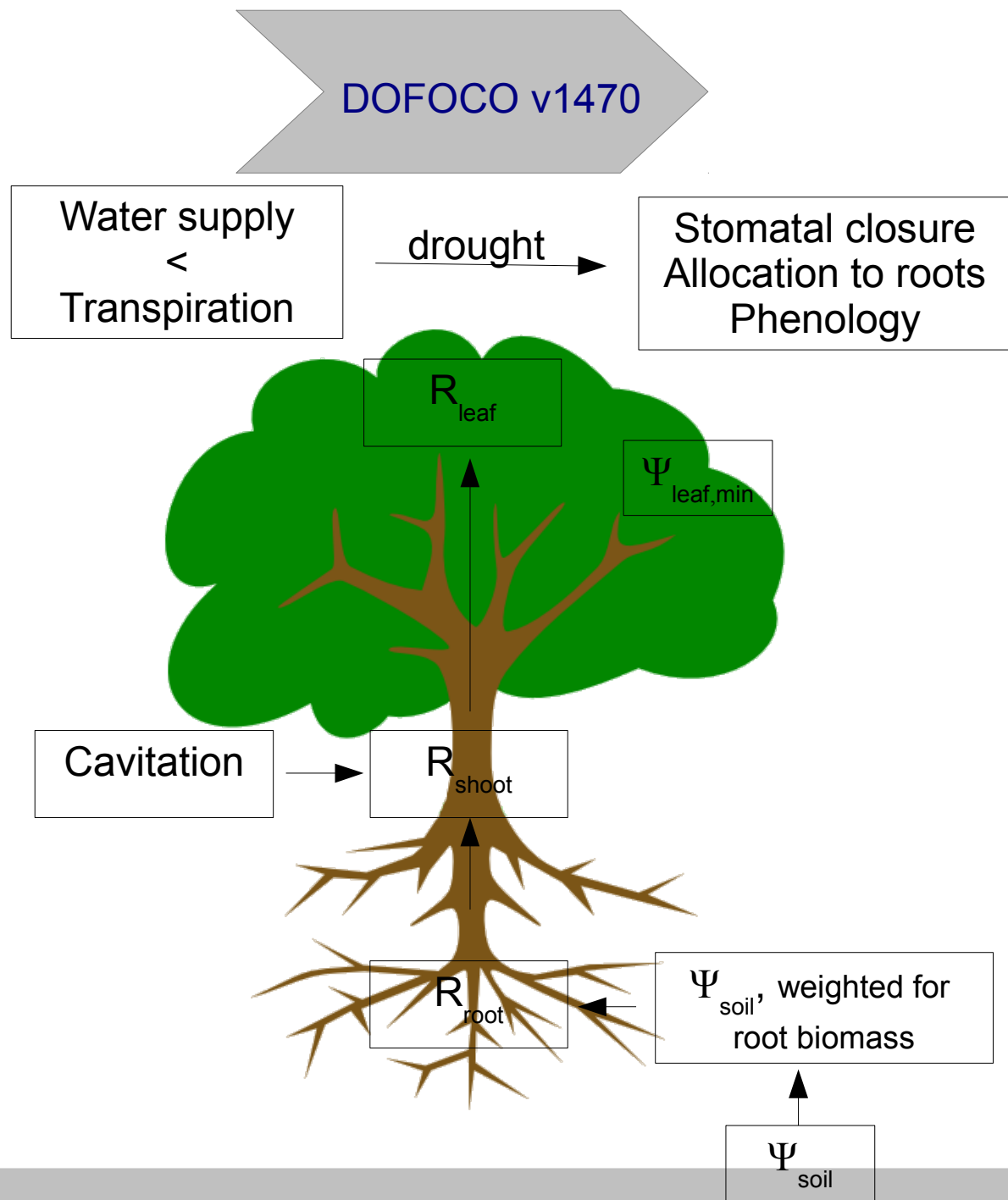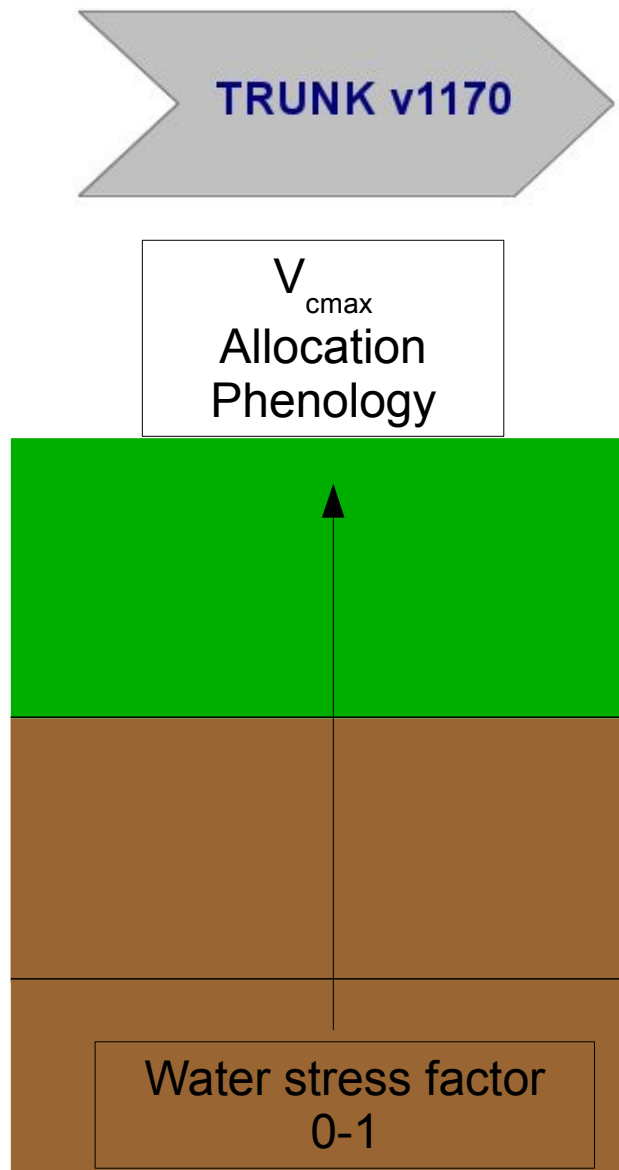
Canopy Structure

Trunk r1170
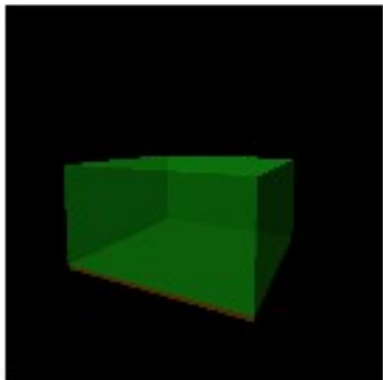
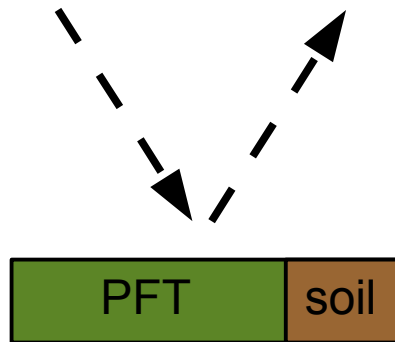No structure, solid mass of vegetation

DOFOCO r1470

-Canopy structure based on allometric relationships

-Prognostic number of individuals

-No actual tree positions (Poisson distribution)

Hydraulic architecture

TRUNK v1170

V_{cmax}
Allocation
Phenology

Water stress factor
0-1

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Water supply
<
Transpiration

drought →

Stomatal closure
Allocation to roots
Phenology

R_{leaf}

$\Psi_{leaf,min}$

Cavitation → R_{shoot}

R_{root}

Ψ_{soil}, weighted for root biomass

Ψ_{soil}

Changes in albedo calculation

ORCHIDEE trunk

- prescribed albedo values that varies with LAI

- no separation between direct and diffuse light

ORCHIDEE DOFOCO
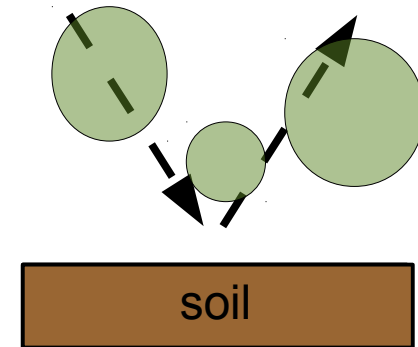
- transmitted, absorbed and reflected light calculated from stand structure

- direct and diffuse albedo are calculated

- fluxes are calculated for each vertical canopy layers

Changes in snow albedo calculation and its effect on canopy albedo

ORCHIDEE trunk

- only shortwave snow albedo (*Chalita and Treut 1994*)

- snow cover fraction depends only on snow fall, fraction is always smaller than unity
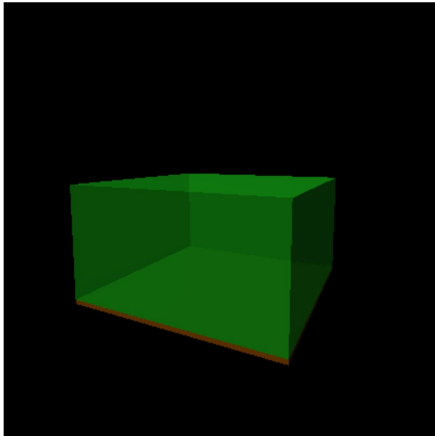
- snow albedo is a only fraction of grid cell

ORCHIDEE DOFOCO

- visible and near-infrared snow albedo (*Dickinson et al. 1993* and *Chalita and Treut 1994*)

- snow cover fraction (SCF) depends on roughness height, SCF can reach unity (*Yang et al. 1997*)

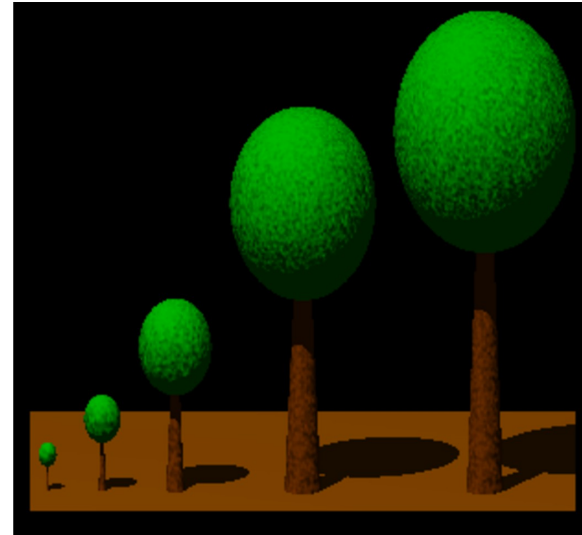- albedo of snow changes the background albedo

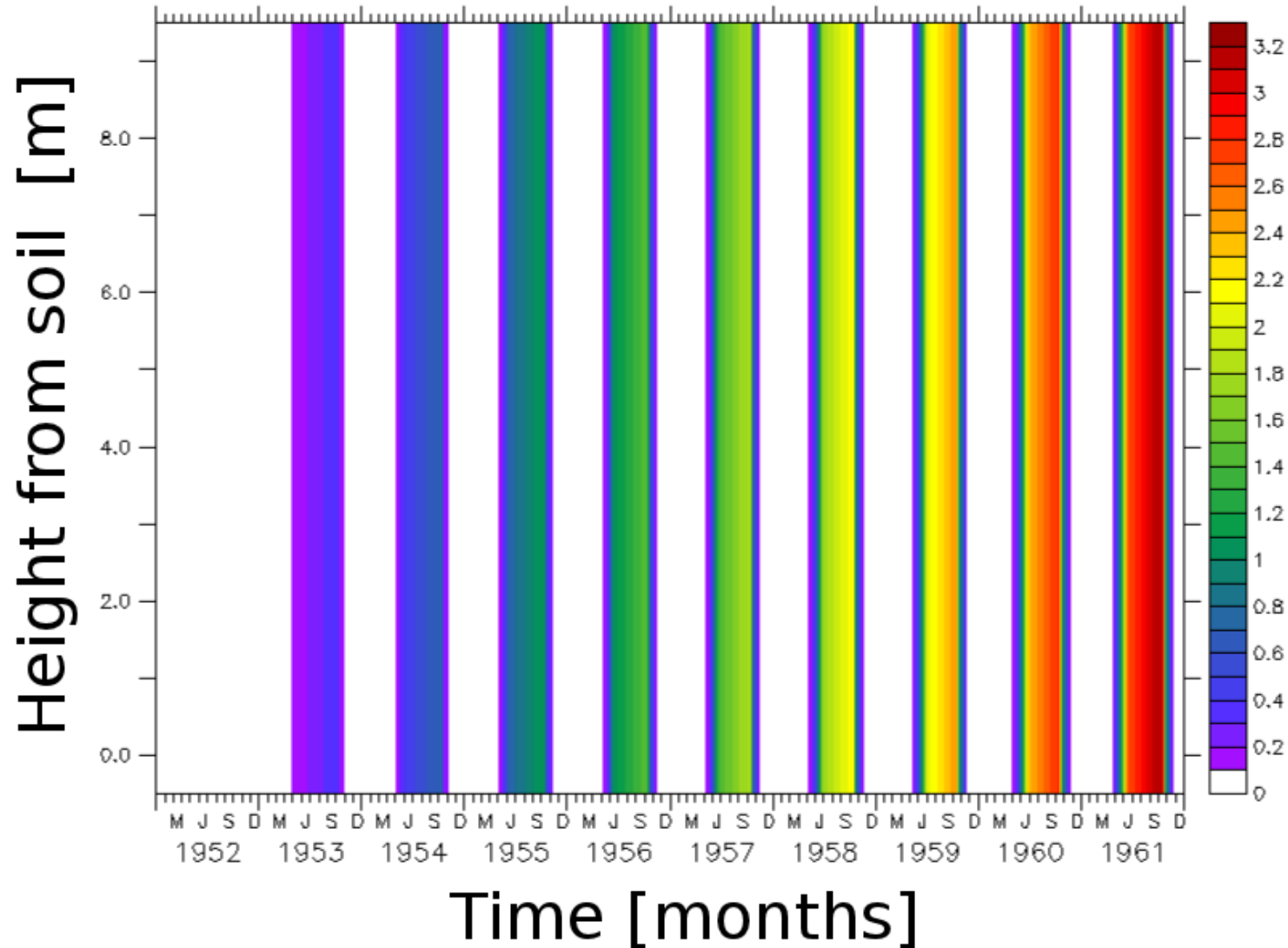# Canopy Structure, light penetration

Trunk r1170

-Beer's law
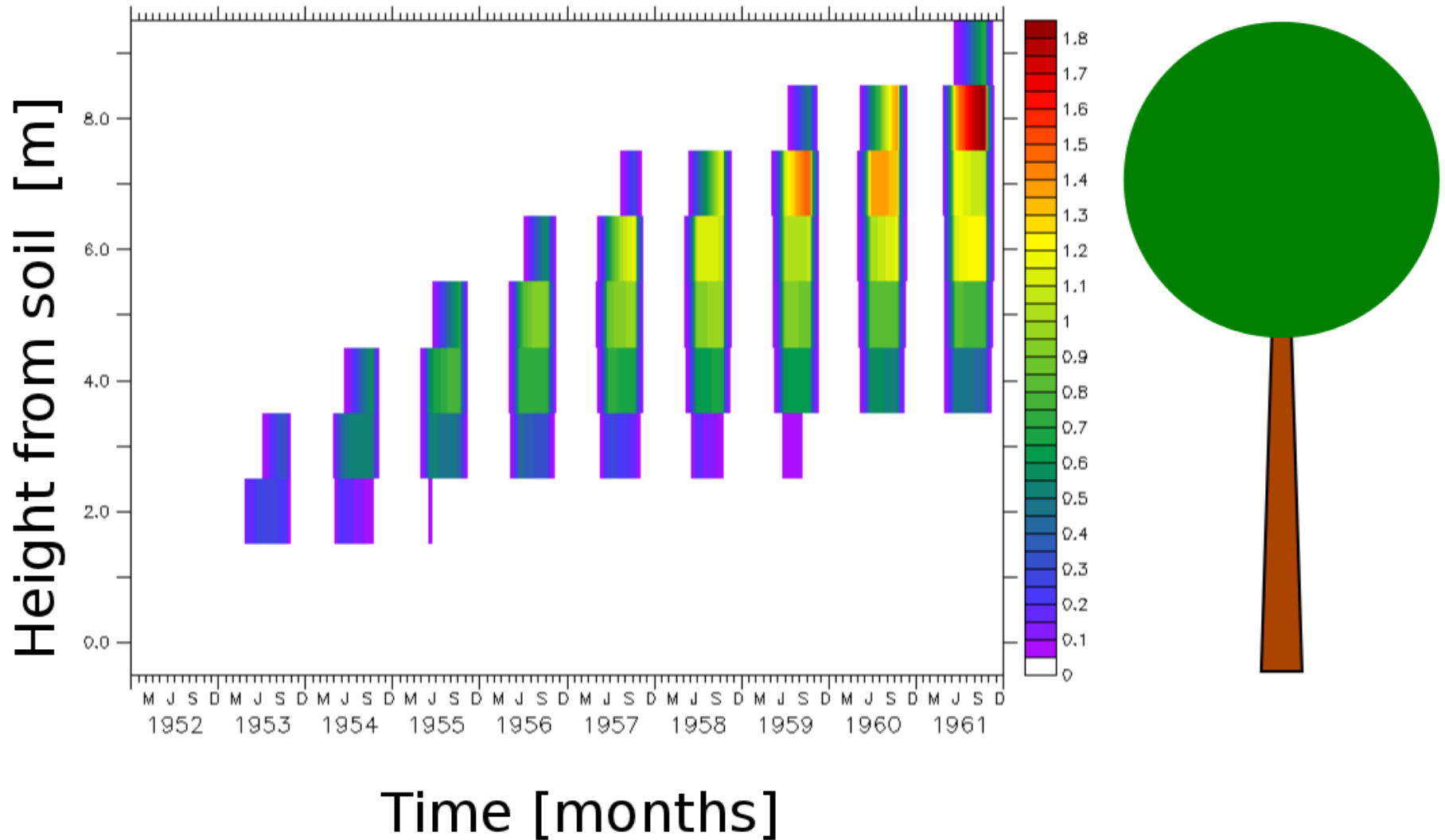
DOFOCO r1470

h_1 h_2 h_3 h_4 h_5

-Multiple height classes
-Finds the average canopy shadow cast
-Canopies are a homogenous turbid medium
-Assumes Poisson distribution of canopies
-Sizes here are exaggerated

Vertical LAI distribution
Trunk r1170

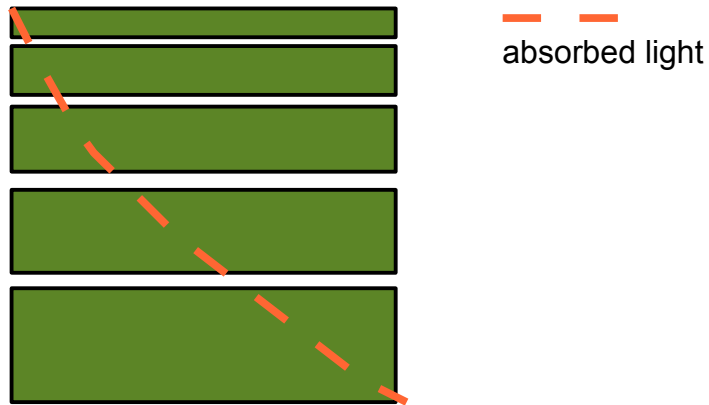Height is prescribed, no vertical resolution

Vertical LAI distribution
DOFOCO r1470

Height is allometrically calculated from biomass

5

Changes in photosynthesis calculation

ORCHIDEE trunk

- - absorbed light

ORCHIDEE DOFOCO

- prescribed, static LAI layers

- absorbed light taken from Beer's law, no reflection taken into account

- inconsistent with albedo calculation

- LAI per layer calculated from stand structure

- only absorbed light calculated by two stream model

- consistent with albedo calculation

- analytic solution of photosynthesis
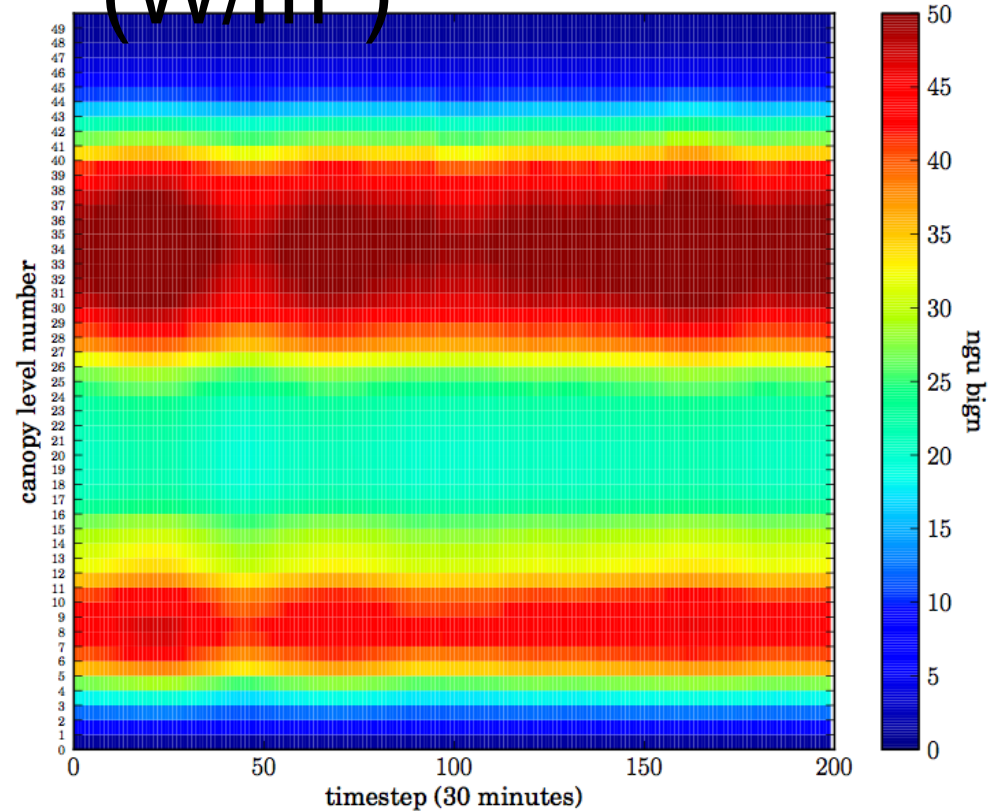
Summary schematic
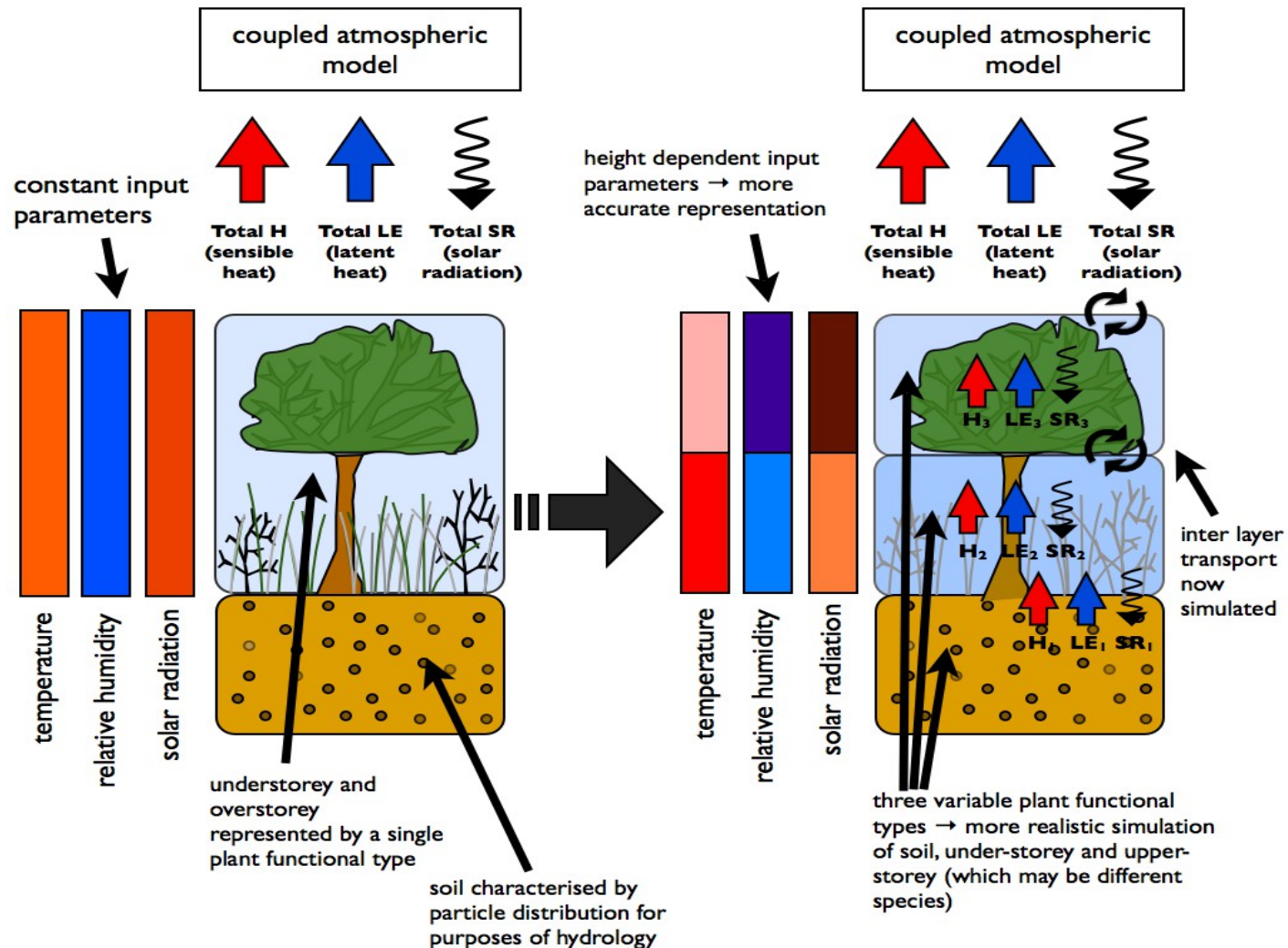
- energy conserved within and between each level
- simulation of within canopy transport characteristics, and of LW and SW radiation
- model uses implicit scheme, so suitable for coupling to LMDZ
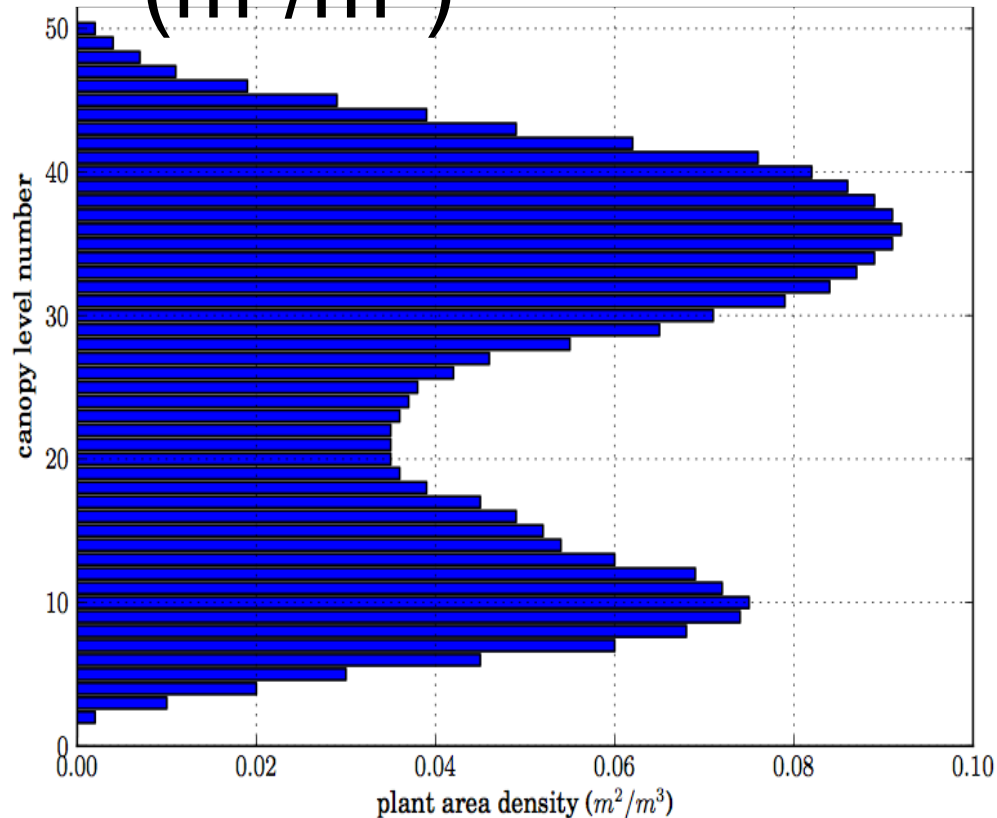
Plant area density (m²/m³)
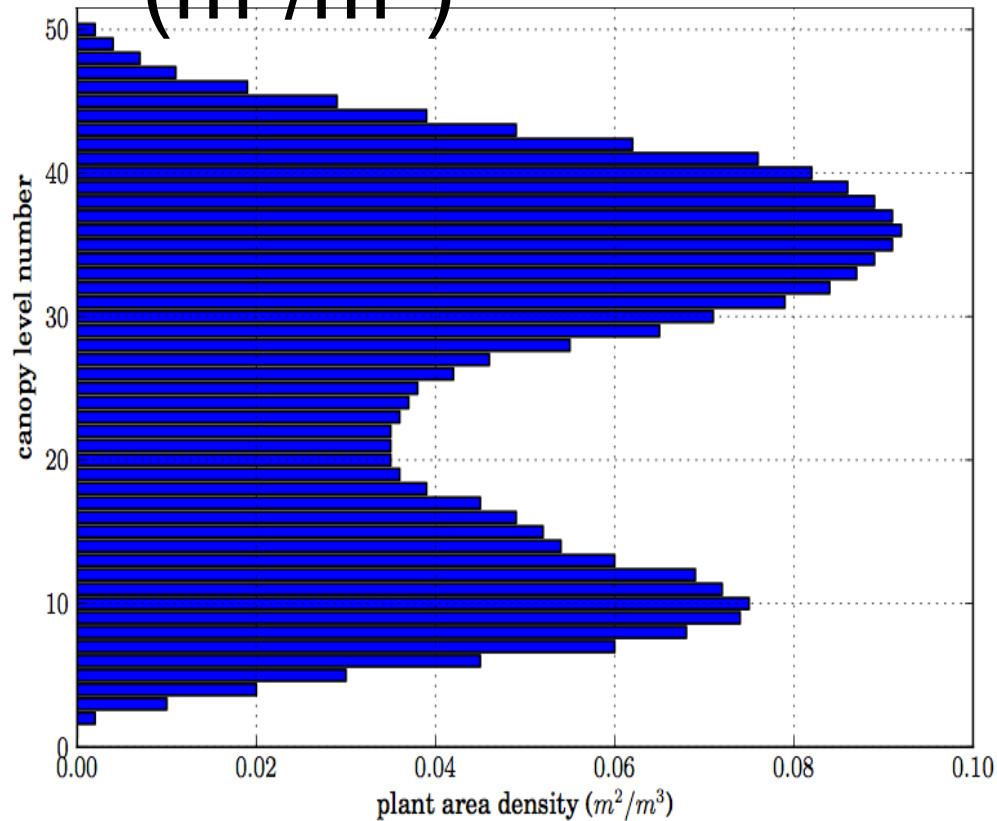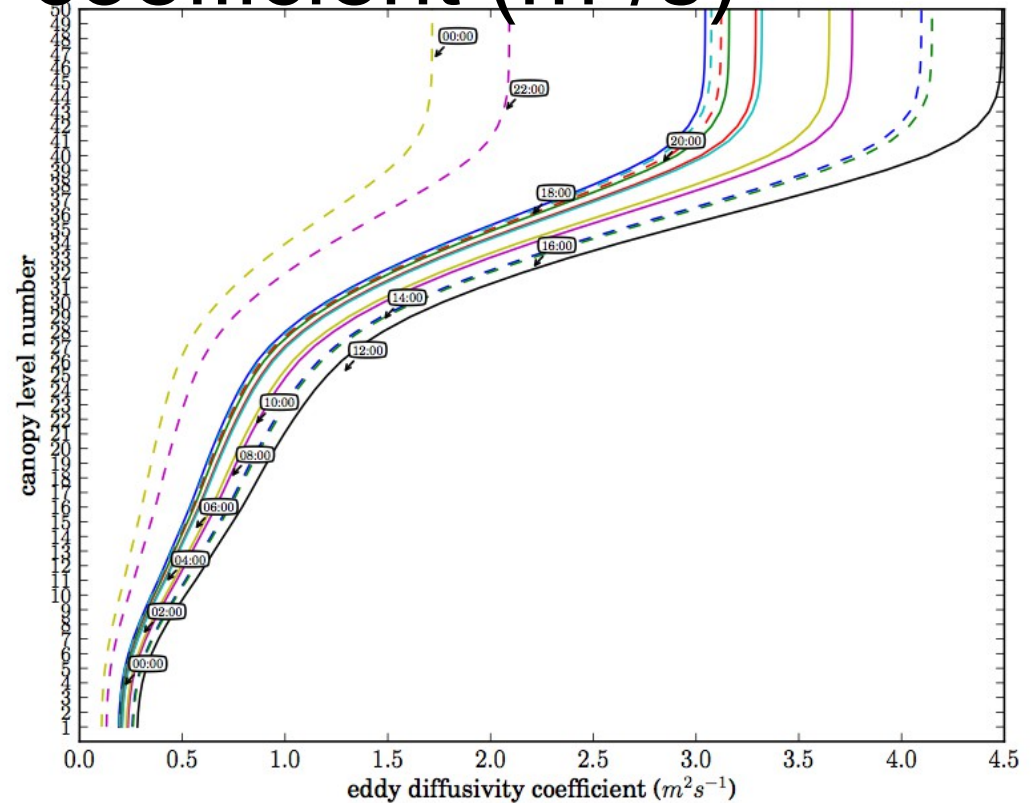
Emitted radiation (W/m²)

- each level is absorber and emitter of longwave radiation (plot shows emission only)
- emission according to plant area density distribution, diurnal fluctuation due to changes in leaf temperature

Plant area density (m²/m³)

Eddy diffusivity coefficient (m²/s)

- - profile shown at different times of day
- transport closure model based on canopy structure
- implementation of further factor to account for near field canopy turbulence effects

TRUNK v1170

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Level of biological diversity

Plant functional type

Species
(European tree species)

Parameter source

?

TRY, JRC-tip, JRC-yield table, forest inventory data, ICP forest data, literature

Optimization

Consistent/reproducible data-driven optimization chain