Institut Pierre Simon Laplace

Institut de recherche en sciences de l'environnement

Land surface in IPSL-CM6

New features, land use representation, and very few model results

Impacts of Land Use and Land Management on Earth System Evolution, Biogeochemical Cycles, Extremes and Inter-Sectoral Dynamics

September 16-20, 2019 Snowmass, CO

What's new since CMIP5 ?

Optimized **albedo** (using MODIS)

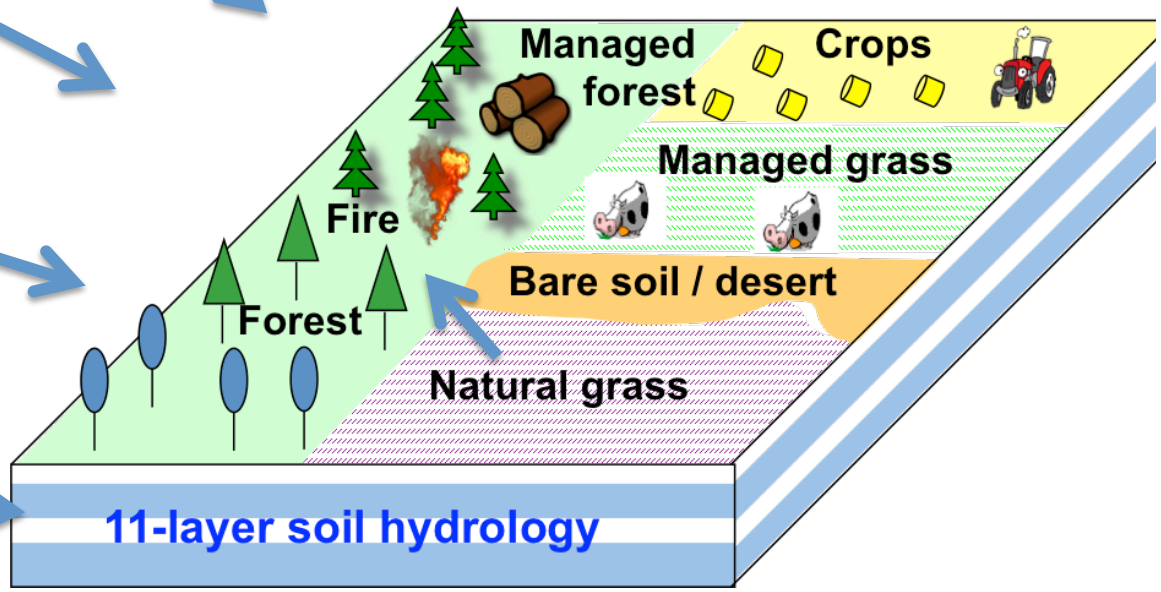
Optimized Carbon cycle **parameters**

Land cover based on ESA-CCI

New 3 layers snow model

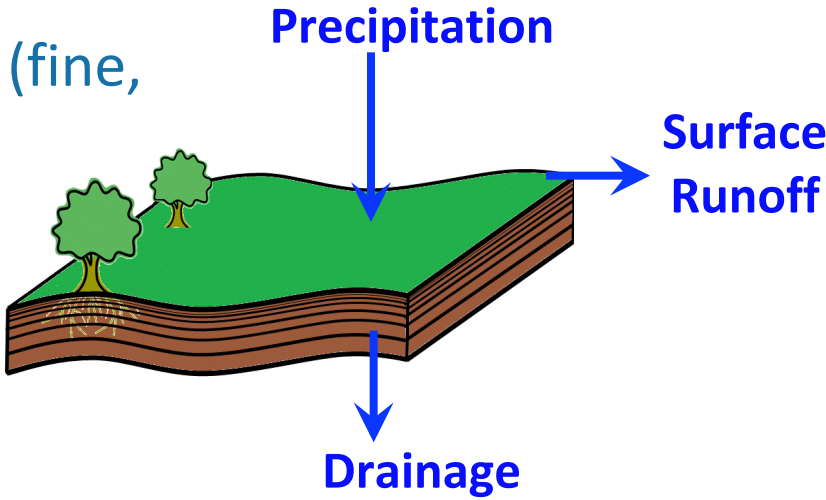
New **Aerodynamic resistance**

11-layer **soil hydrology** With soil **freezing**



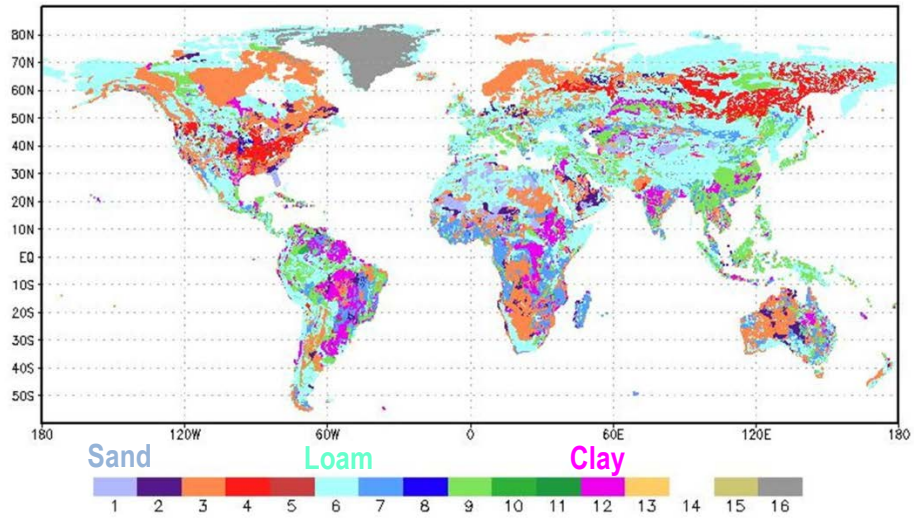
A multi-layer hydrological scheme

- **Physically-based description of soil water fluxes using Richards equation**
- Formulation of Fokker-Planck
- Hydraulic properties based on van Genuchten-Mualem formulation
- Related parameter based on texture (fine, medium, coarse)
- Surface runoff = P – E_{soil} – Infiltration
- Free drainage at the bottom

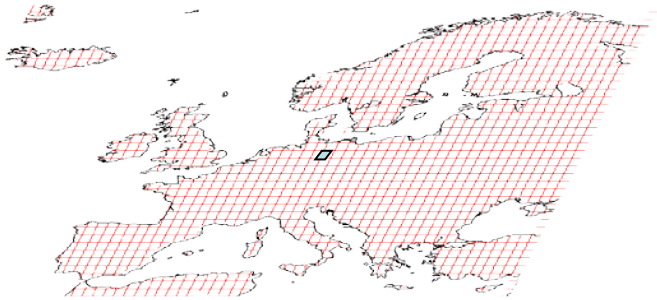


Tiling for soil hydrology

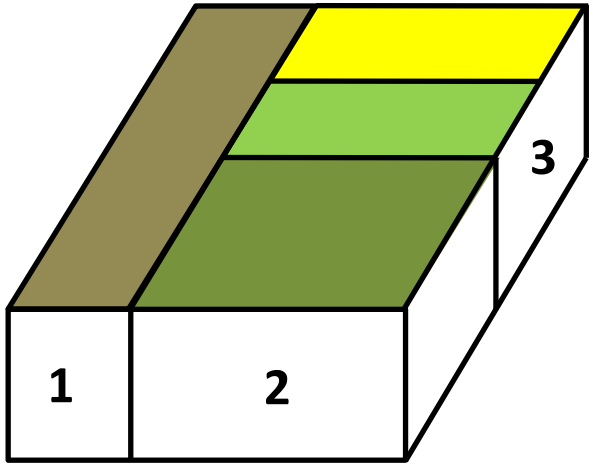
5' USDA texture map (Reynolds et al., 2000)



Dominant texture in each ORCHIDEE grid-cell:
defining the hydraulic properties



Sub-grid scale heterogenity:
3 soil columns based on PFTs
with independent water budget
but same texture



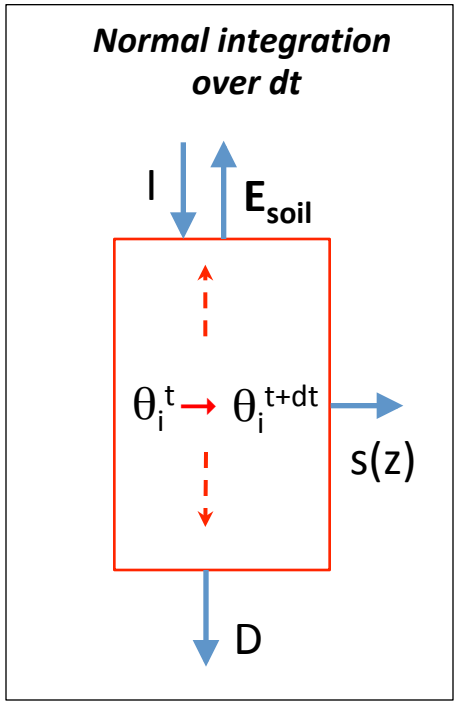
1: Bare soil PFT
2: All Forest PFTs
3: All grassland and cropland PFTs

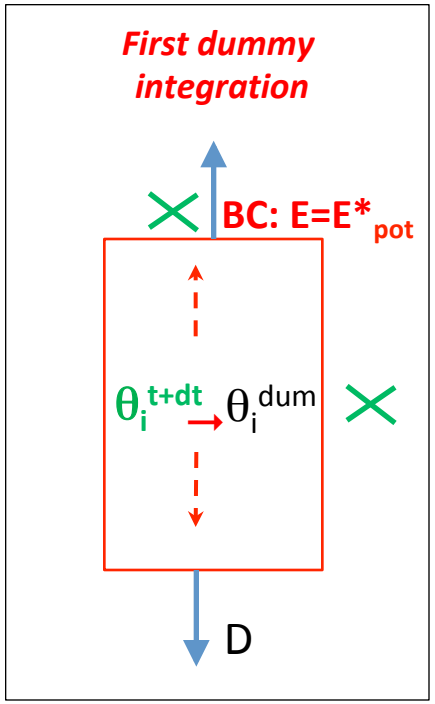
Soil evaporation

- **Controlled by a demand / supply scheme**

  ⇒ No explicit resistance to soil evaporation

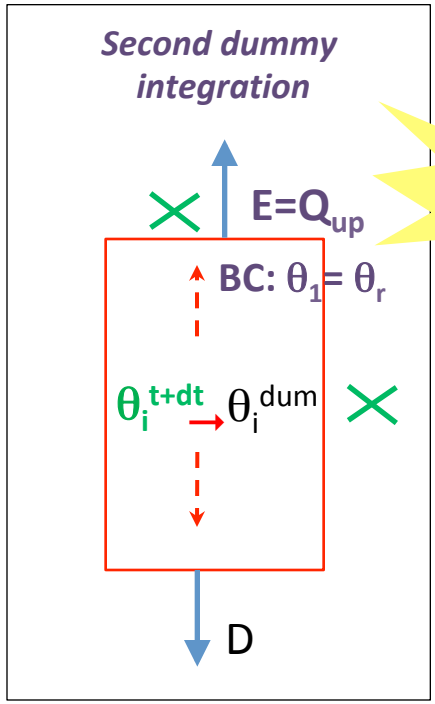
- relies on dummy integrations of the water diffusion scheme





If all $\theta_i^{dum} > \theta_r$
$\beta=E_{soil}/E_{pot}$

Else



Dirichlet case

$\beta=Q_{up}/E_{pot}$

Aerodynamic resistance

$$E_{pot} = \rho \frac{q_{sat}(T_s) - q_{air}}{r_a}$$

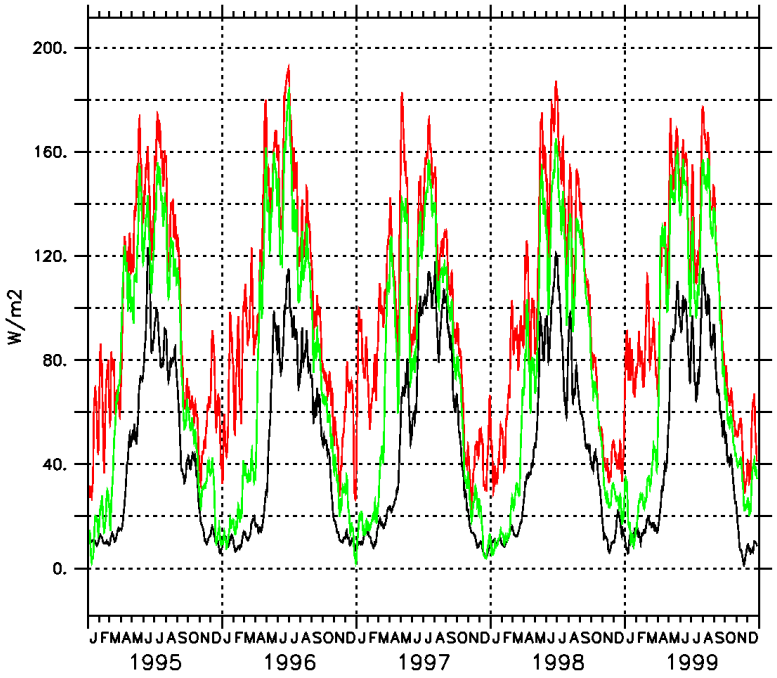
$$r_a = \frac{1}{\kappa^2 u_a}\left[\ln\left(\frac{z-d_0}{z_{0m}}\right)\ln\left(\frac{z-d_0}{z_{0v}}\right)\right]$$

where

- z is measurement height (m)
- u_a is wind speed (ms^{-1})
- k von Karman's constant
- d_0 is displacement height
- z_{0m} and z_{0v} the roughness heights for momentum and water vapor transfer

OBS
11-layer
11-layer with Su

Latent Heat flux @ Walker Branch site (TeDBF)



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function of LAI

OBS
11-layer
11-layer with Su

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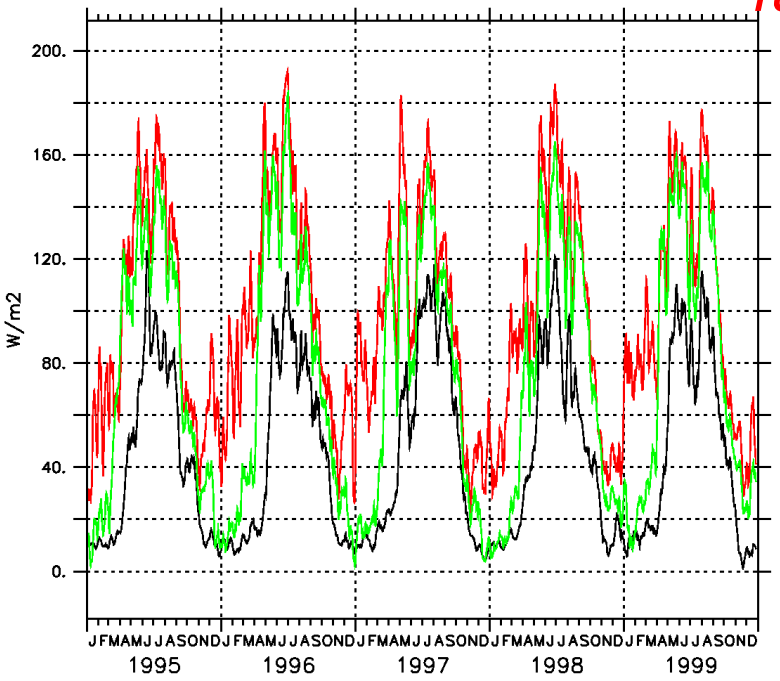
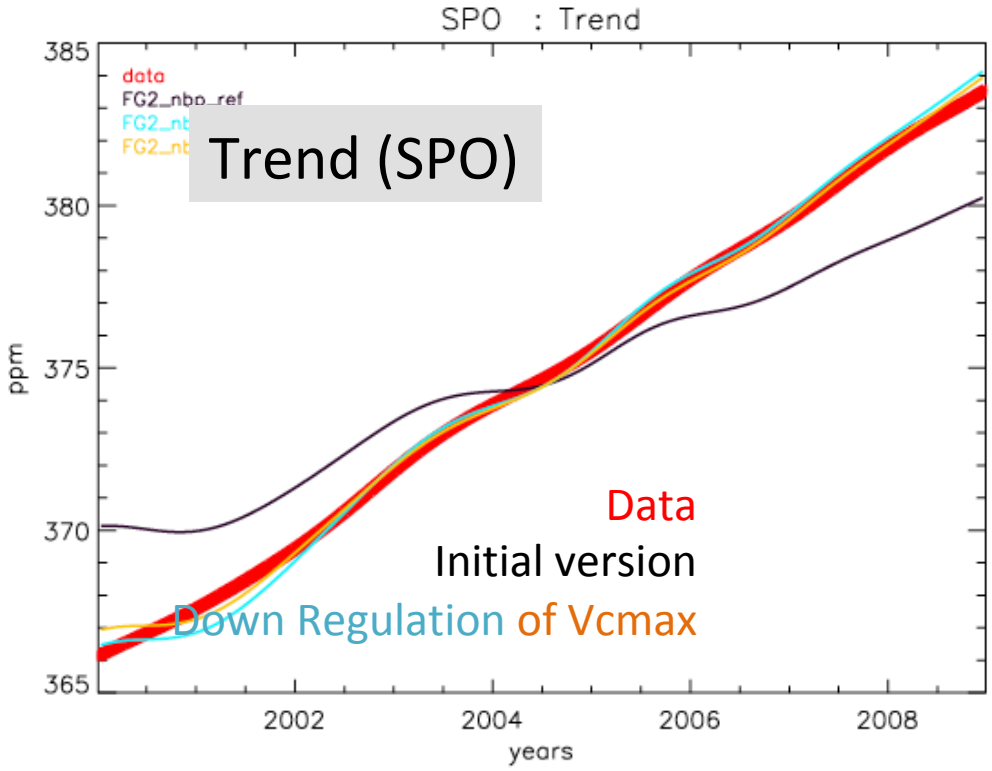


Model calibration for C-cycle

- Optimization of key parameters using TRY database & Bayesian optimizations with FluxNet data
  - Vcmax, LAImax, Respiration, …
  - CO2 down regulation: Vcmax = Vcmax_ref . (1 – Coef . Alog(CO2 / CO2_ref))

Evaluation with atm. CO2 data (using LMDz transport)



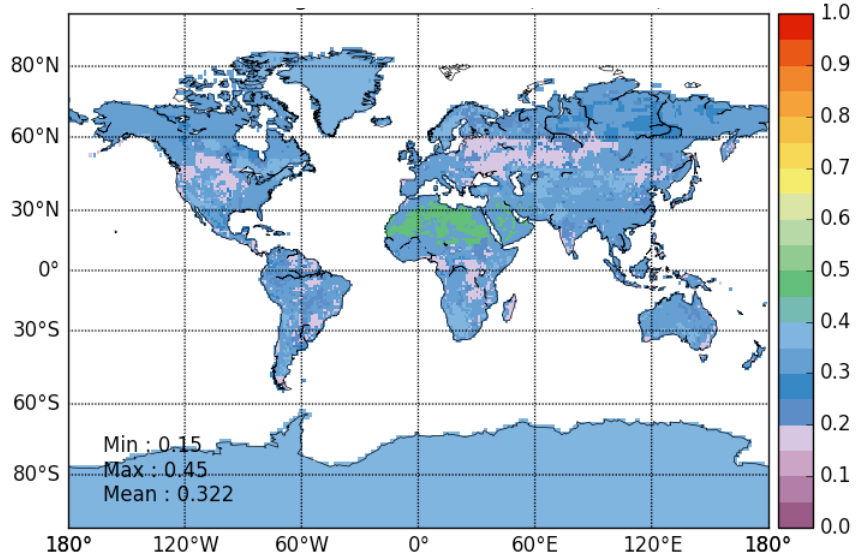
New soil albedo

- $alb_{surf} = alb_{veg} * frac_{veg} + alb_{soil} * (1 - frac_{veg})$
- Optimisation using MODIS albedo

Results For NIR

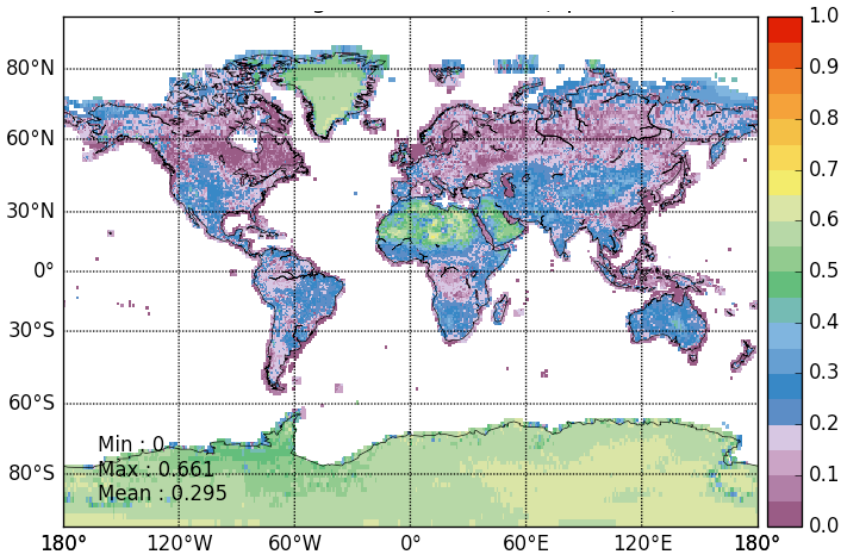
Prior values

Initial soil albedo based on soil color

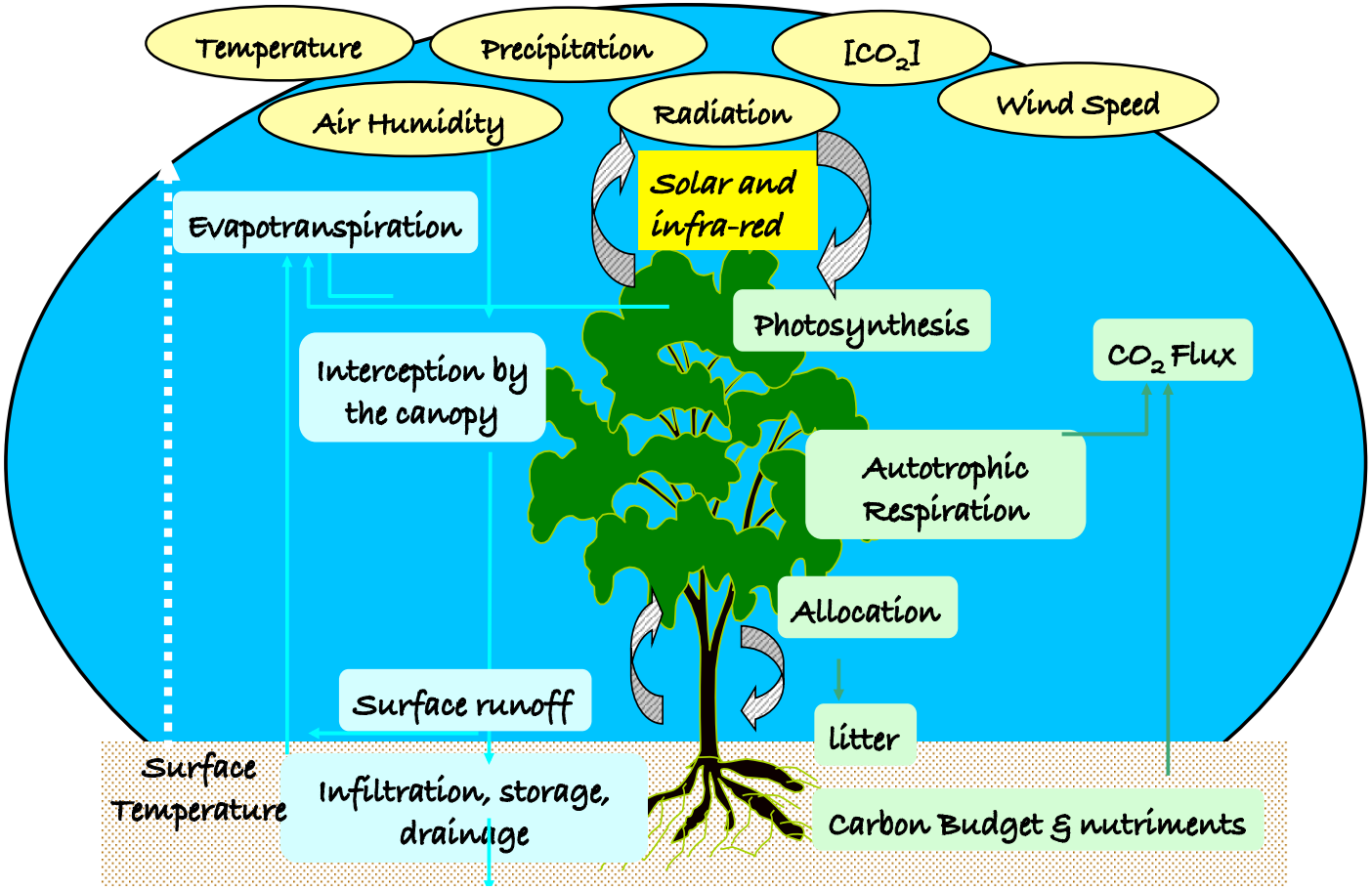


Posterior values

Soil albedo optimised with MODIS



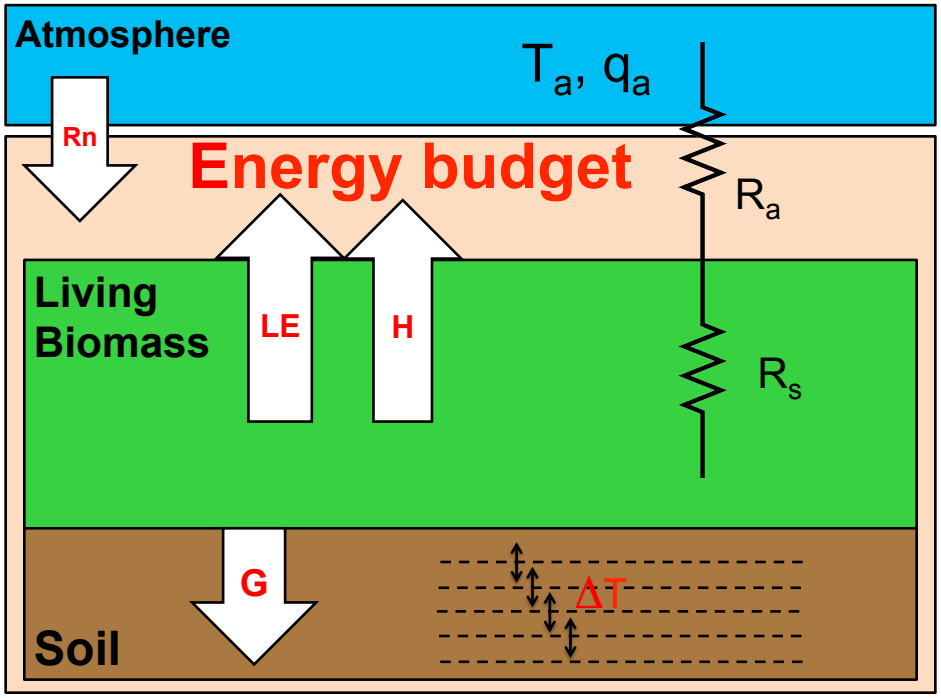
What is not new ?

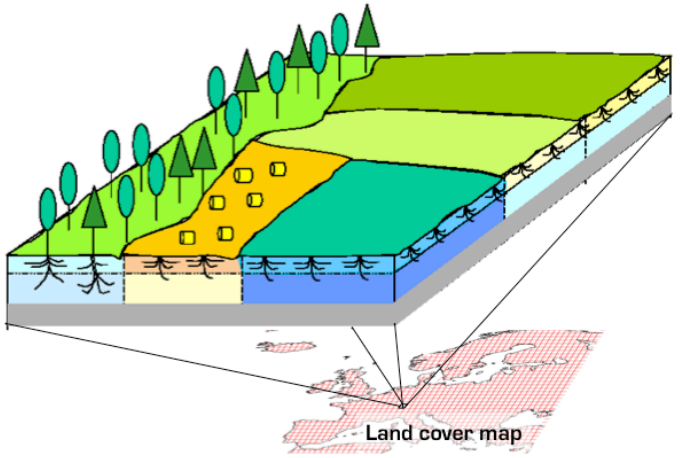


ORCHIDEE

Tiling in IPSL-CM6

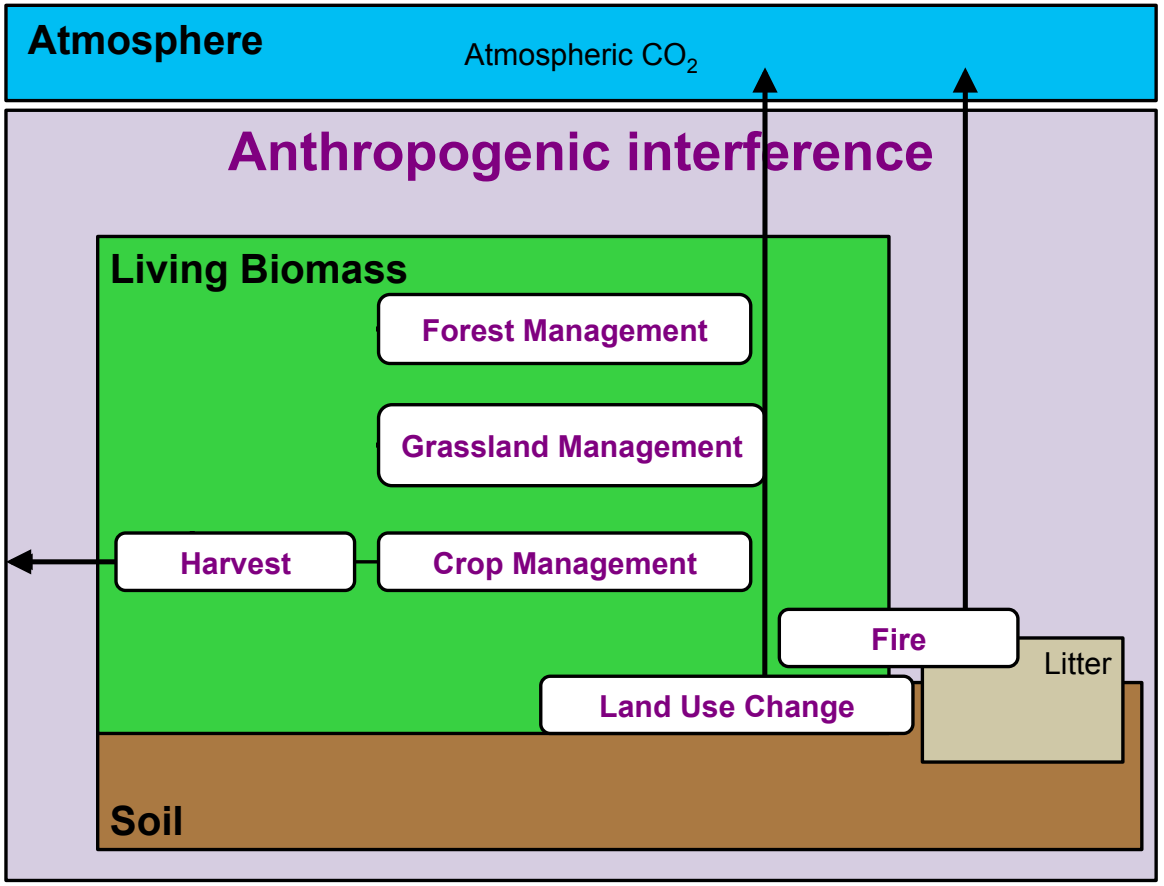
A single energy budget !





=> One surface temperature per grid cell

Land use and land use change



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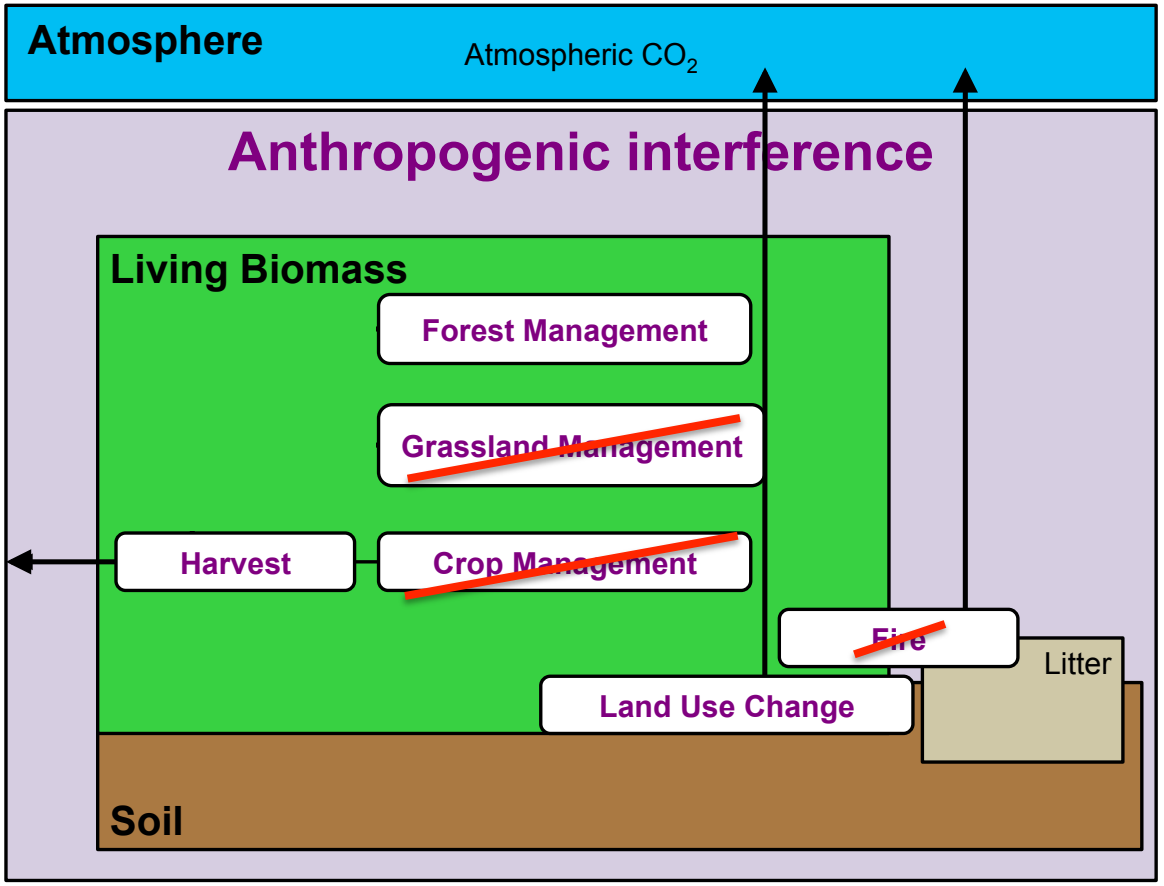

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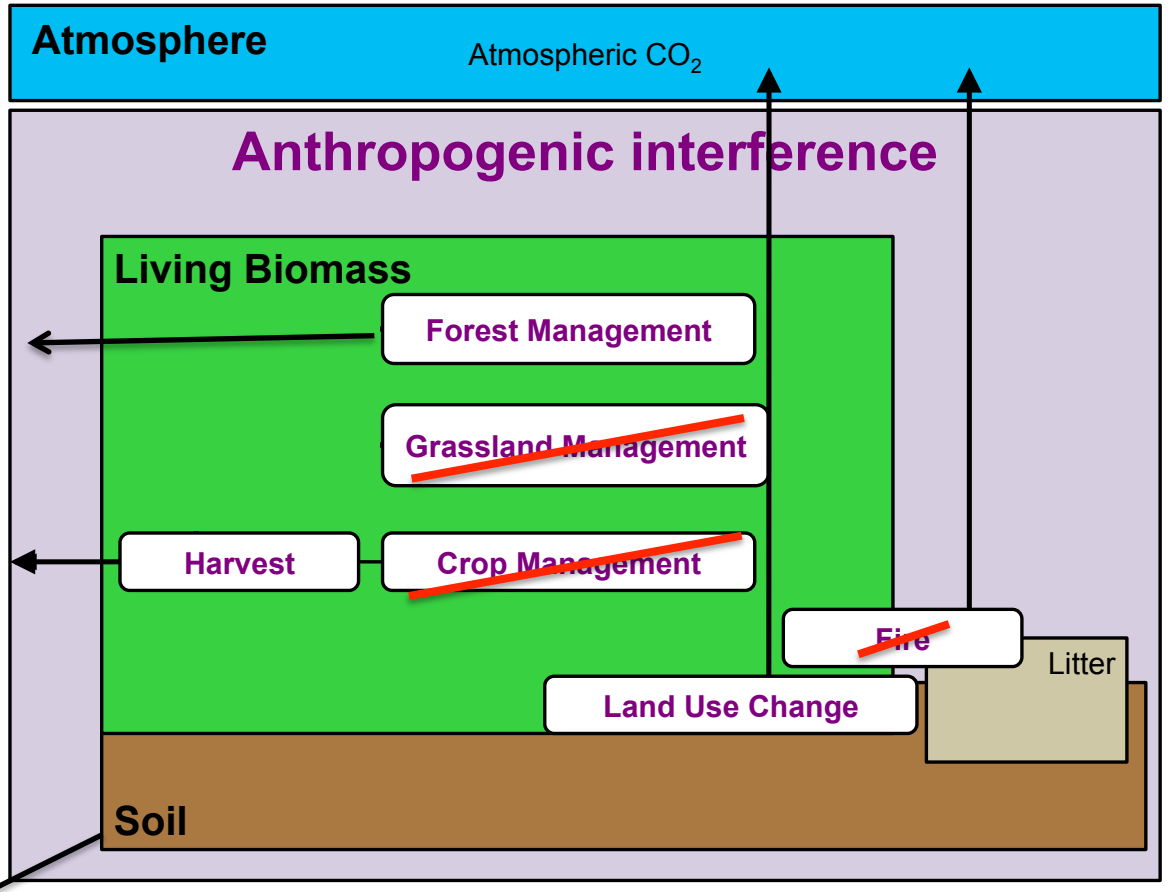


Wood Harvest

using LUH2

Crop Harvest

45 % of NPP is harvested and respired within the year

SOM decomposition rate of crop is 20% higher

Only net LUC

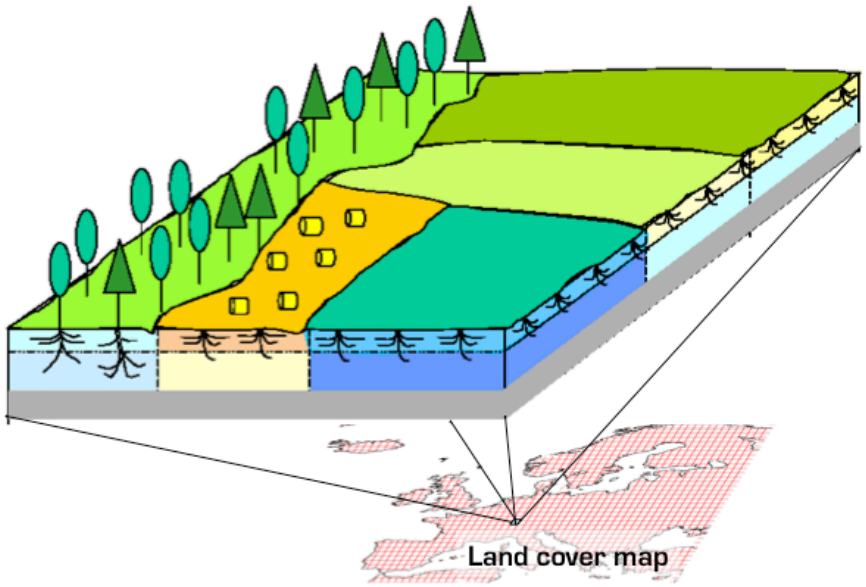
3 woody pools

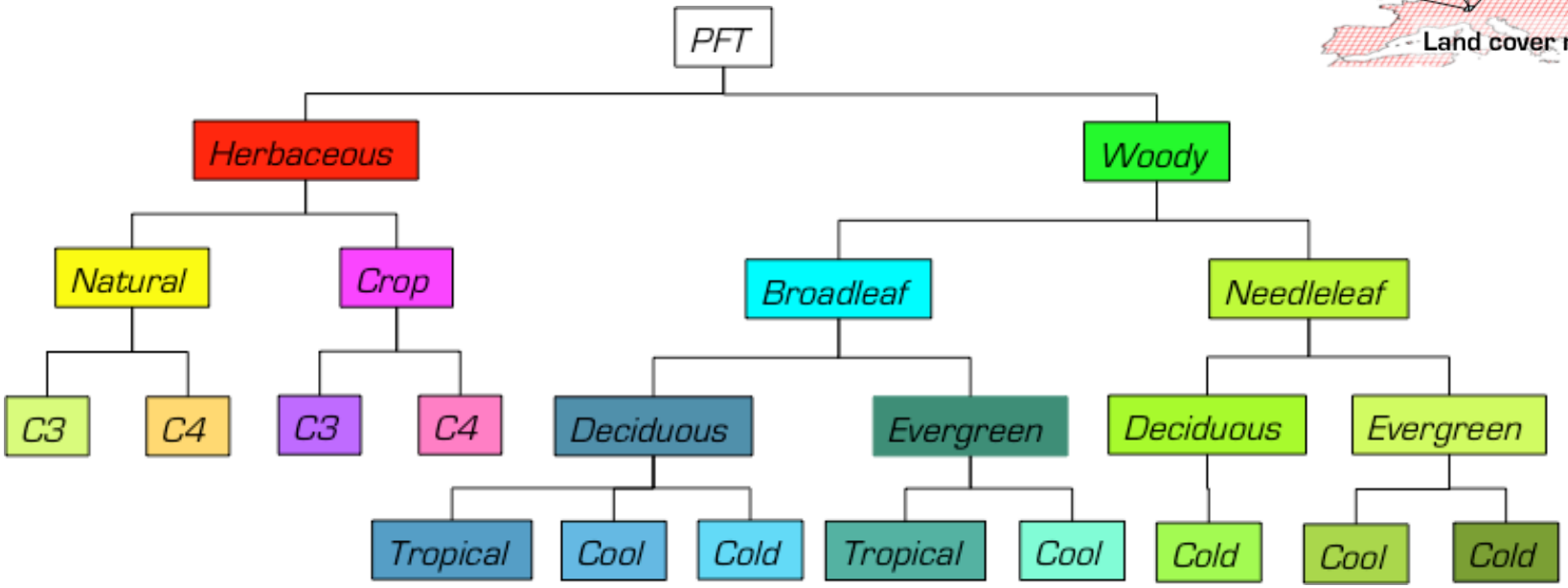
- 1-yr lifespan
- 10-yr lifespan
- 100-yr lisfespan

Fixed fractions over time

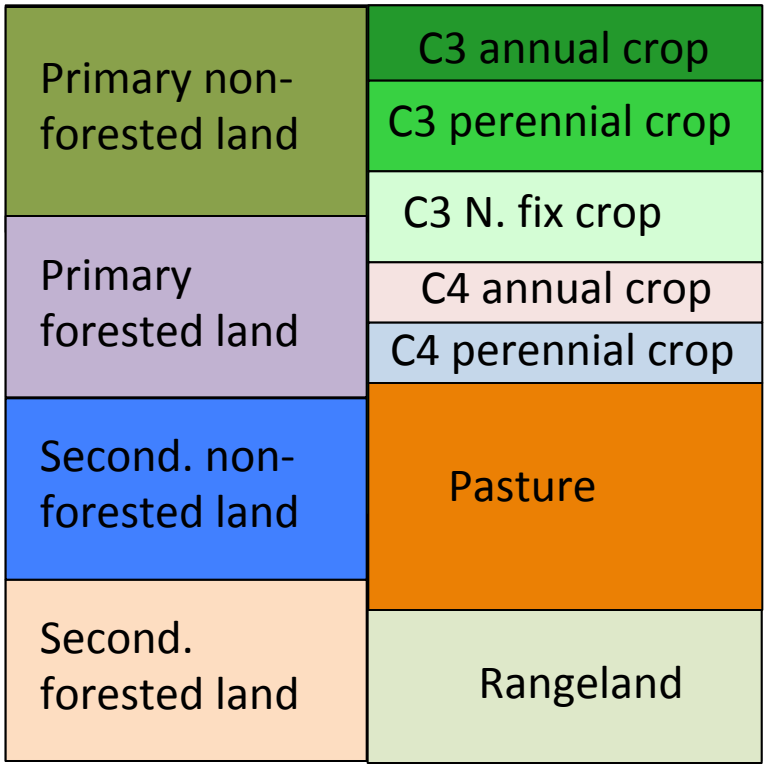
Vegetation classes in IPSL-CM6

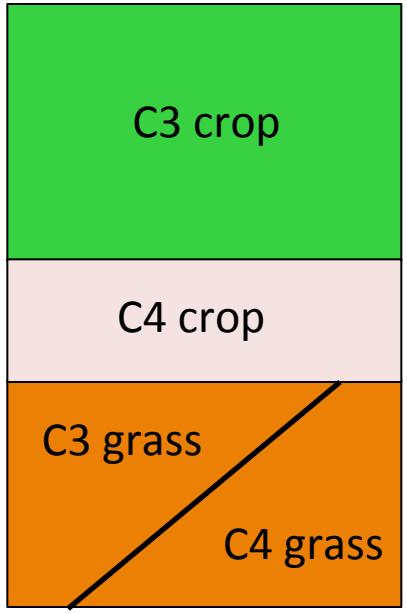
- Plant Functional Types
  - Defined according to systematic, physiological, phenological, climatic conditions





From LUH to PFT map





Based on Still et al., 2009

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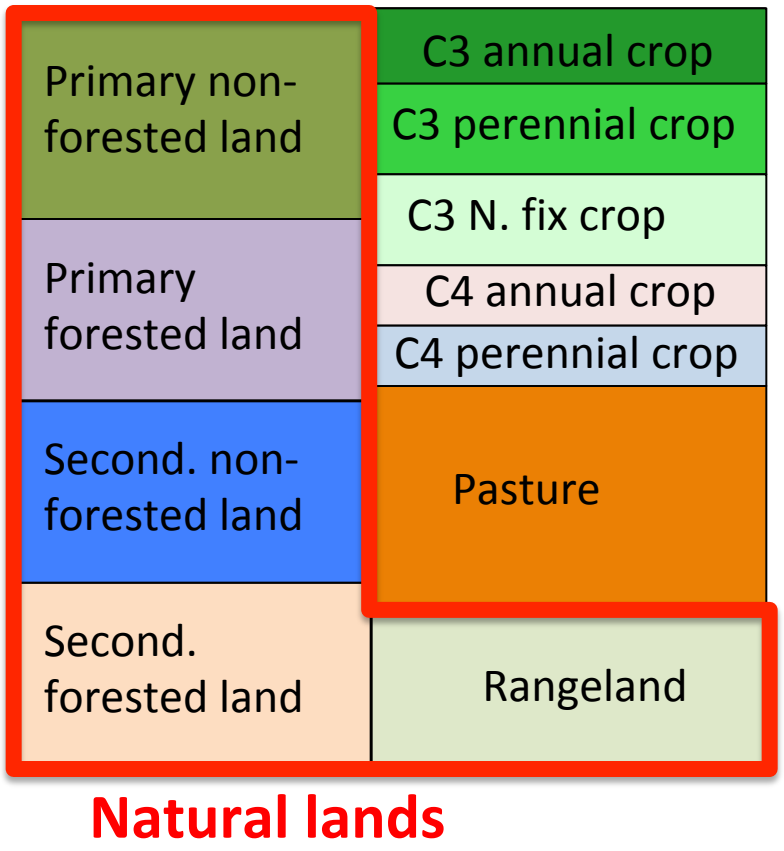
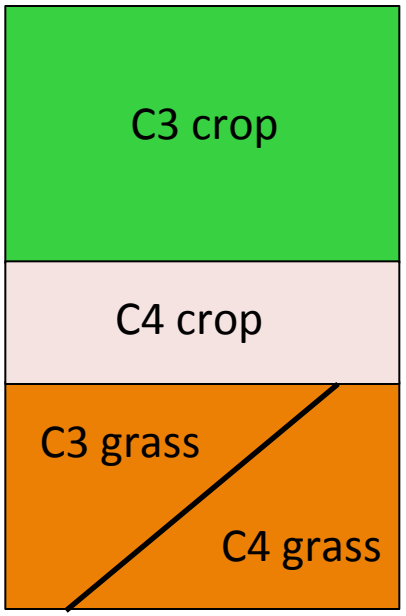


Natural lands



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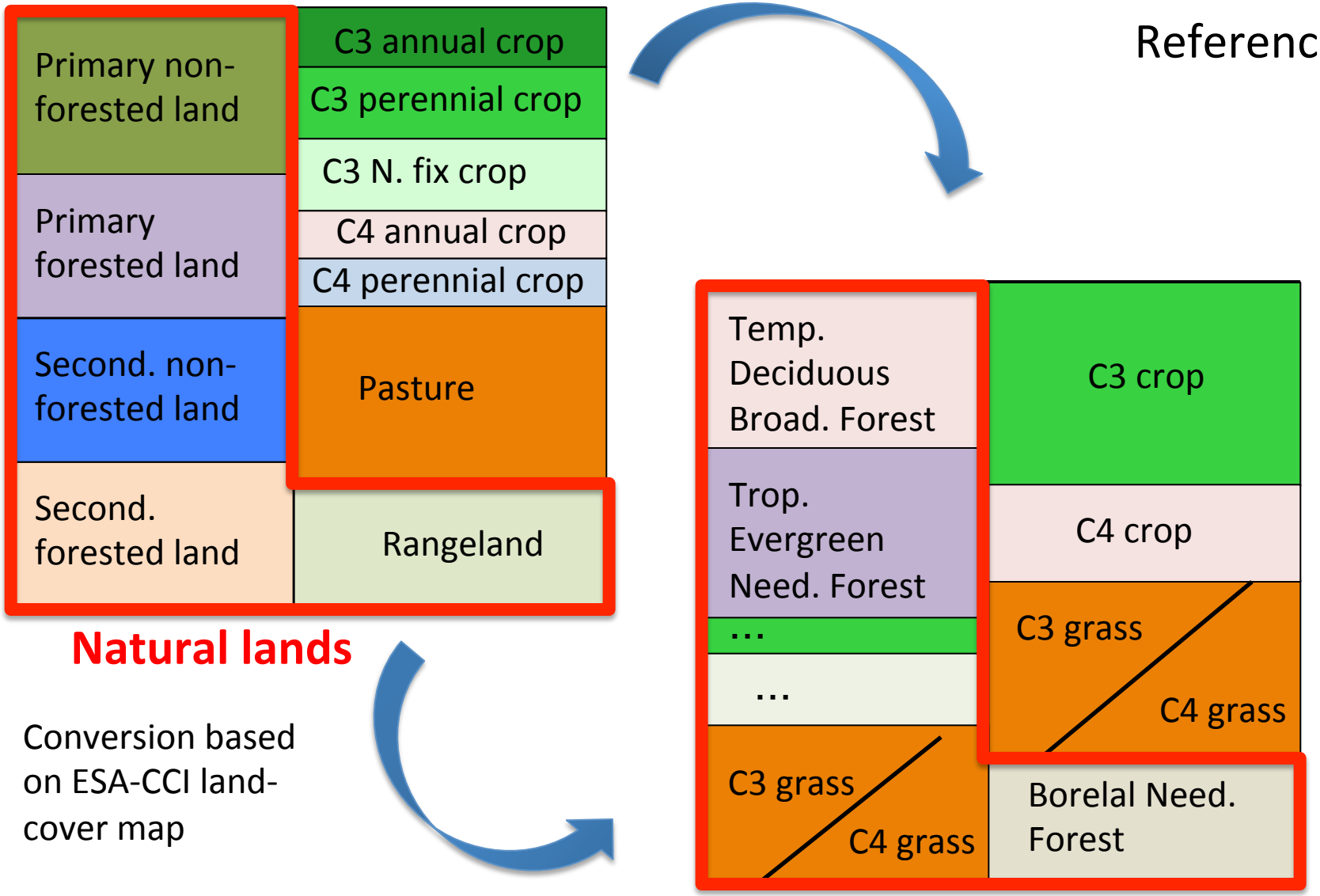

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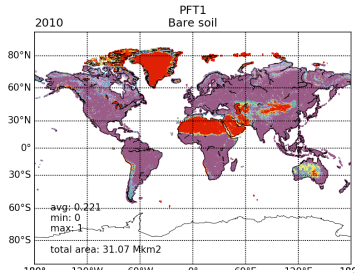
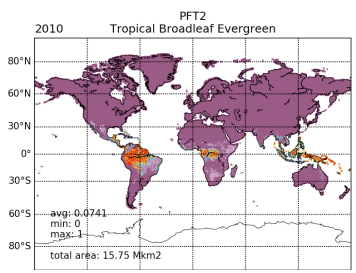
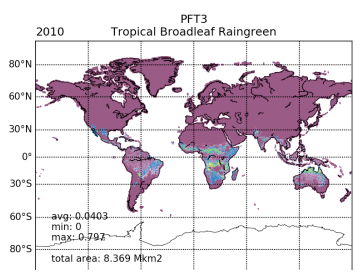
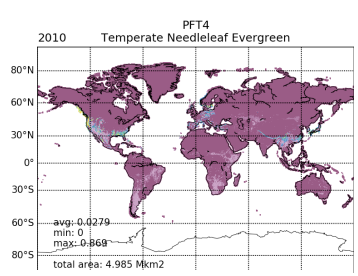
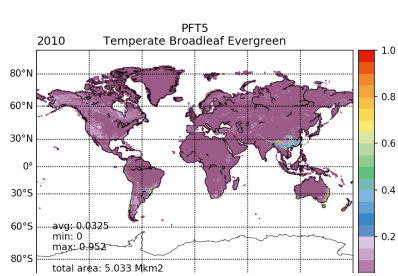
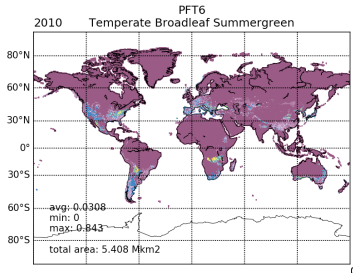


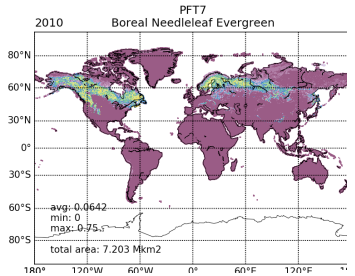


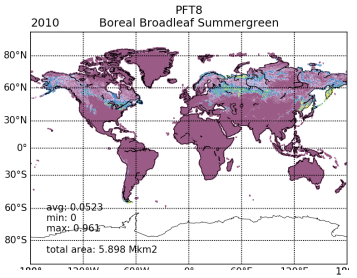


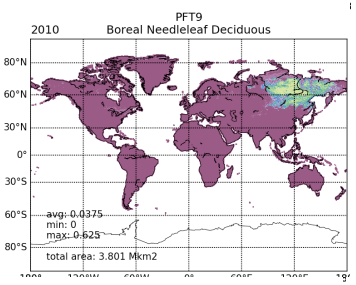


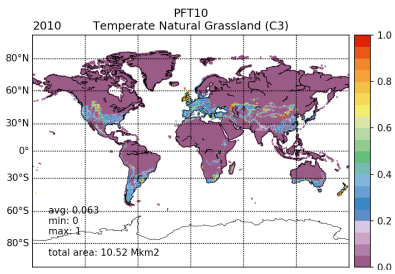


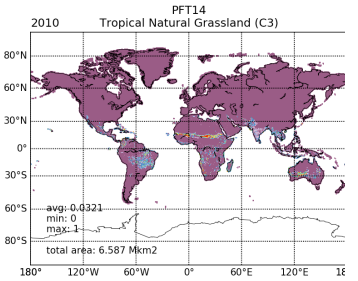


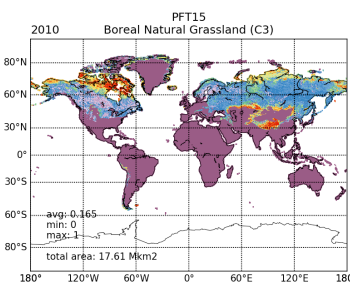


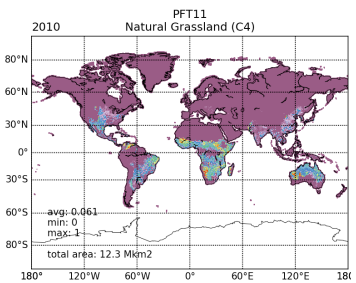


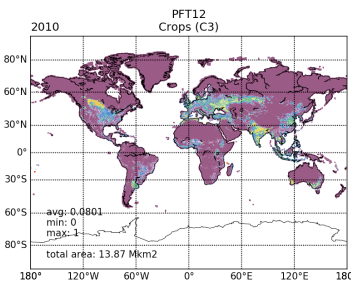


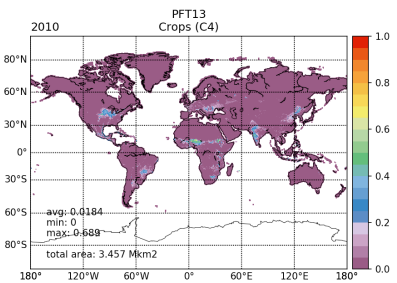










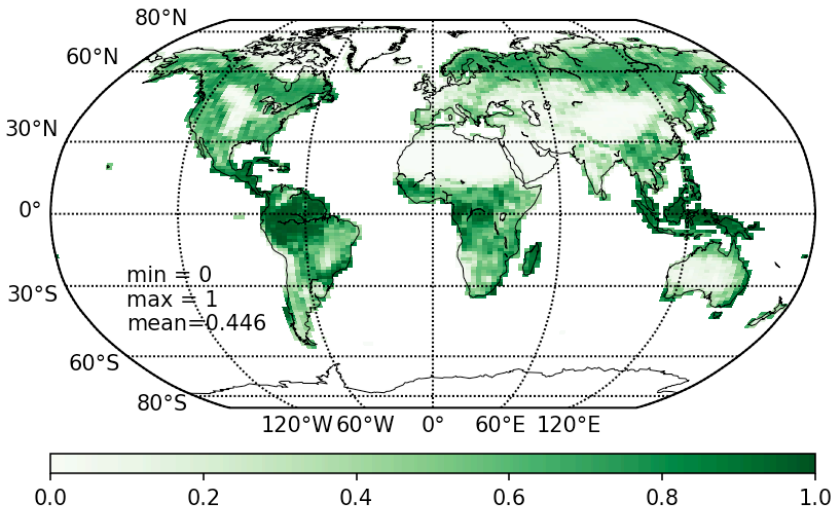


Where are we ?

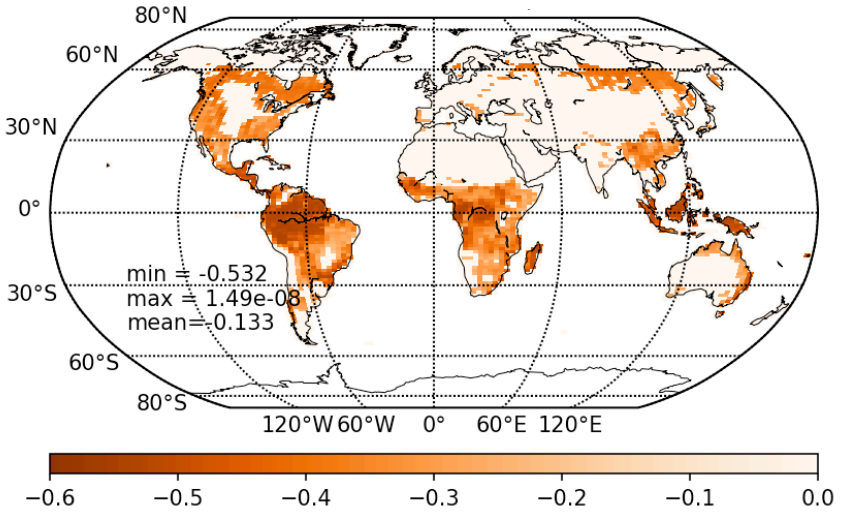
- Tier 1
  - deforest-globe (3 members) *done*
  - hist-noLu (3 members) *done*
  - land-hist *done*
  - land-noLu *to be done*
  - land-hist-AltStartYear *to be done*
  - ssp370- ssp126Lu *on-going*
  - ssp370- ssp126Lu *on-going*
  - esm-ssp585- ssp126Lu *to be done*
- Tier 2 *to be done*
  - land-hist-altLu1, land-hist-altLu2, land-cCO2, land-cClim, land-crop-grass

Preliminary analysis of deforest-globe exp.

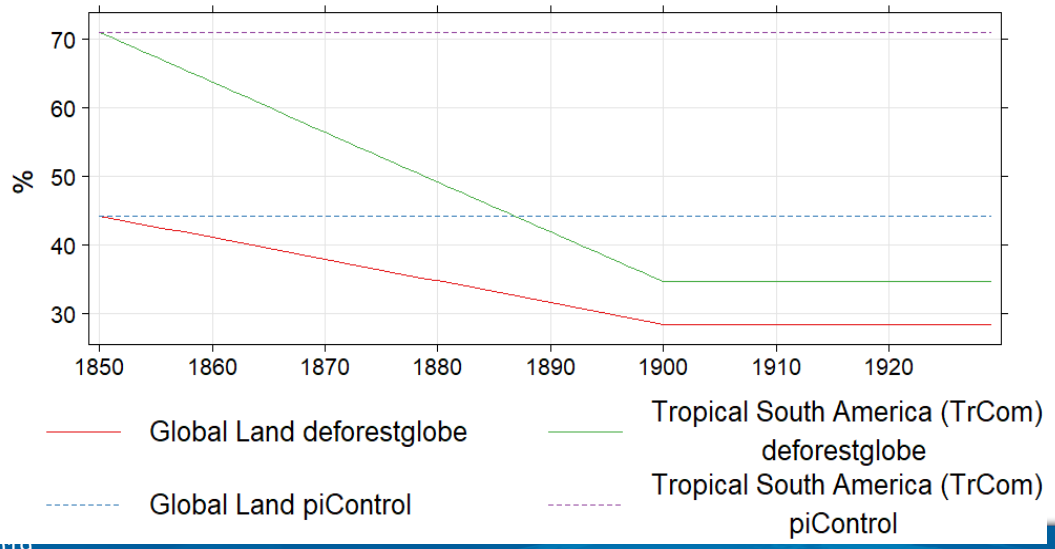
Initial Tree fraction



Tree fraction change

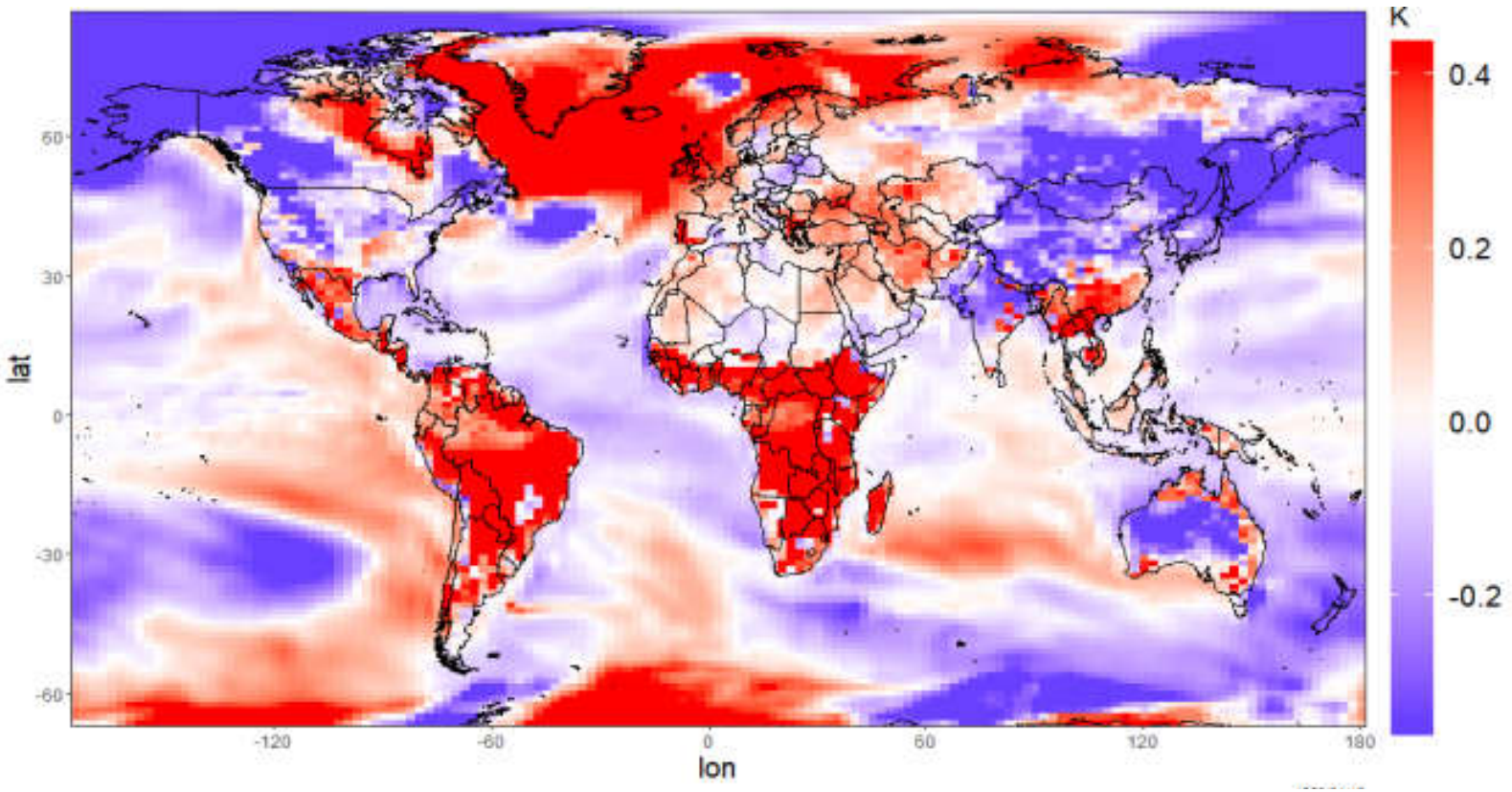


Tree Cover Fraction mean per year



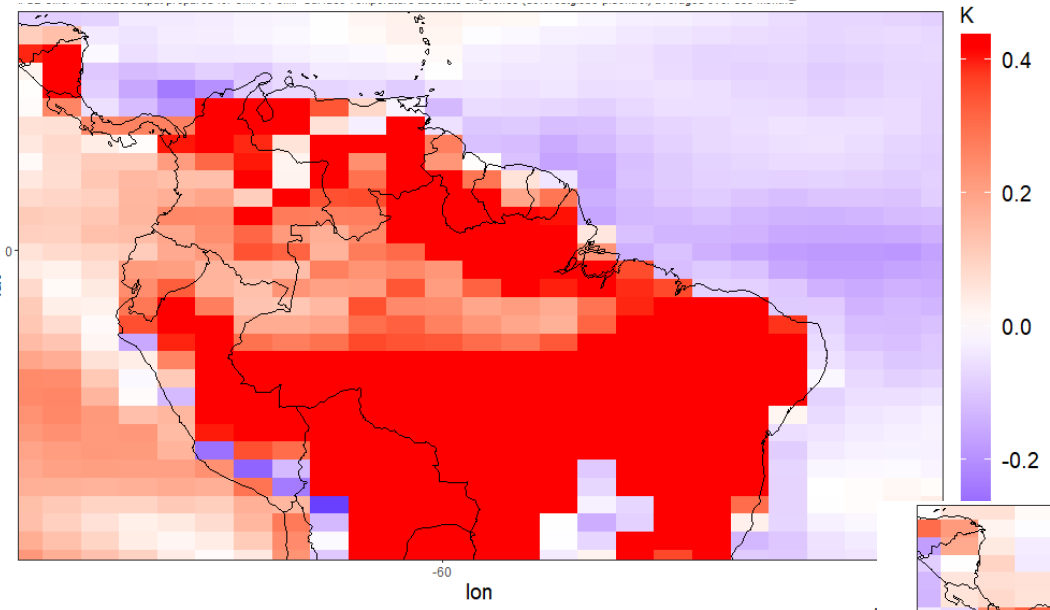
Deforest-globe exp.

Surface temperature absolute difference Mean over 30 years

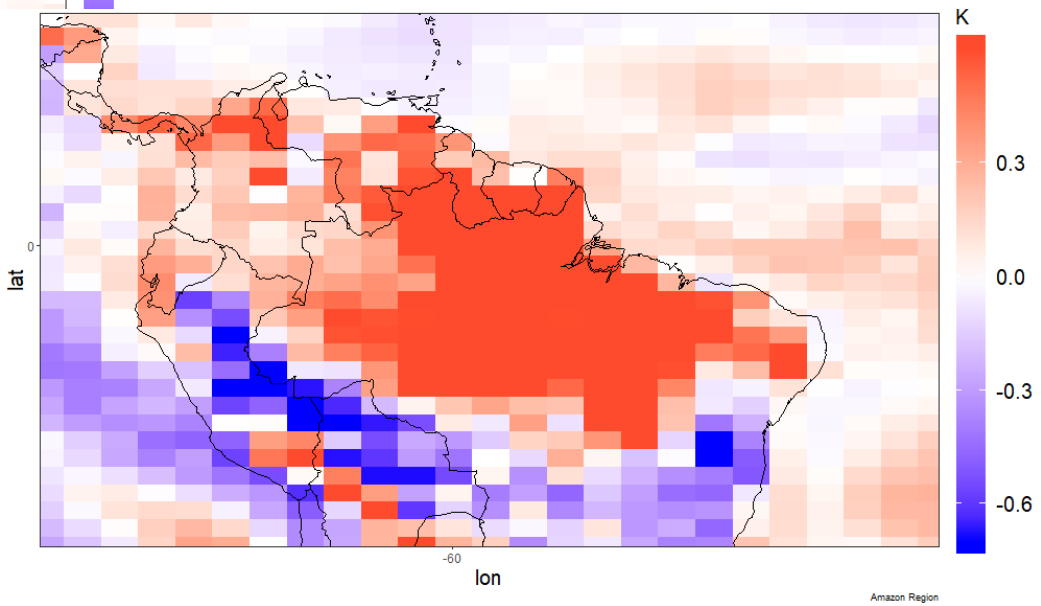


Zoom on Amazon

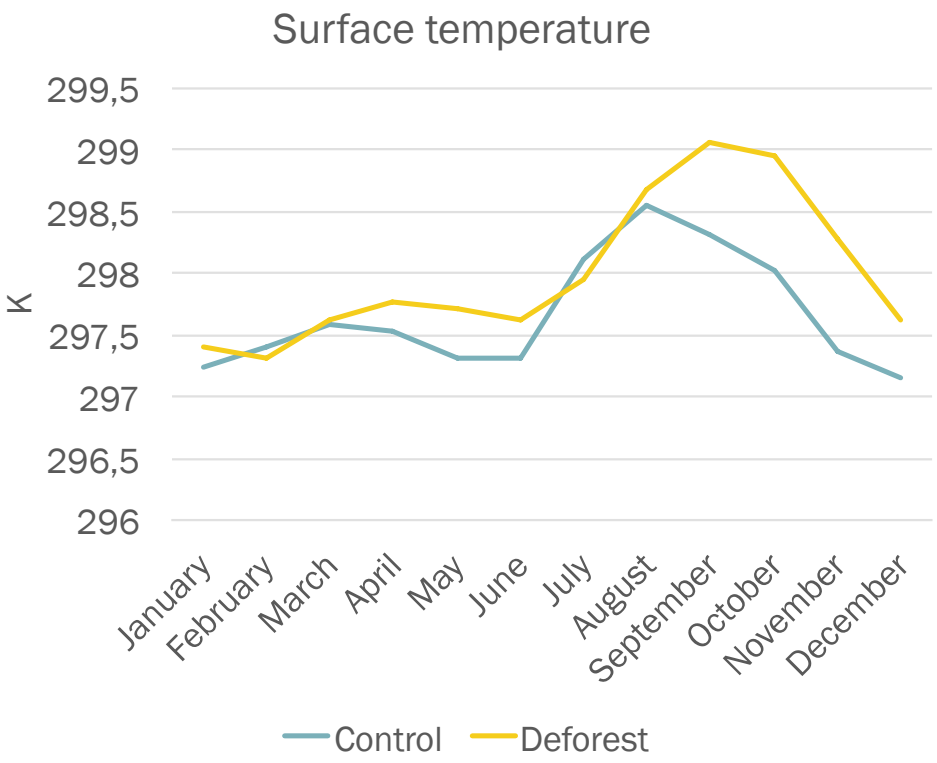
Surface temperature change

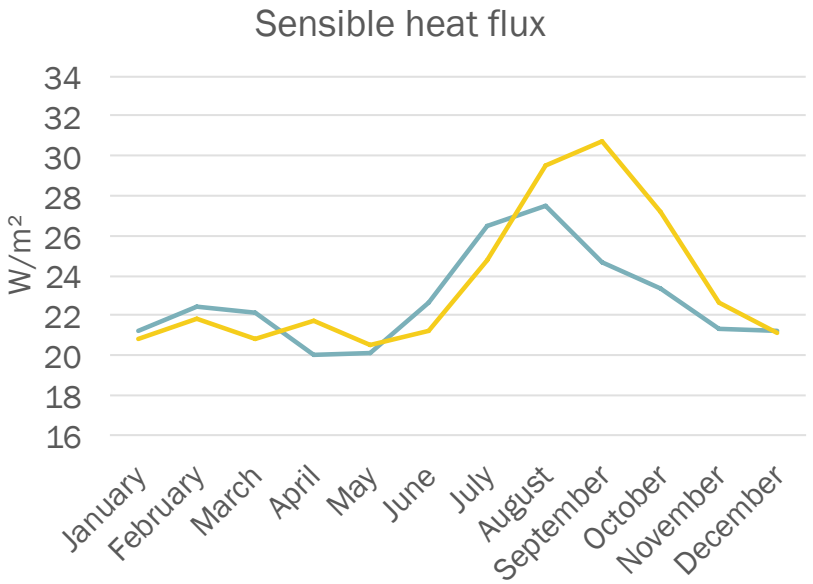


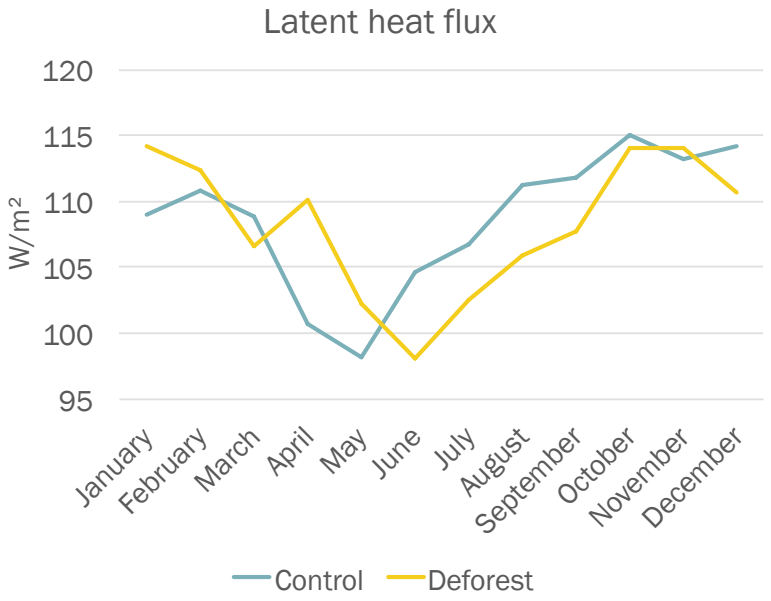
Surface temperature seasonal amplitude change



Seasonal variations





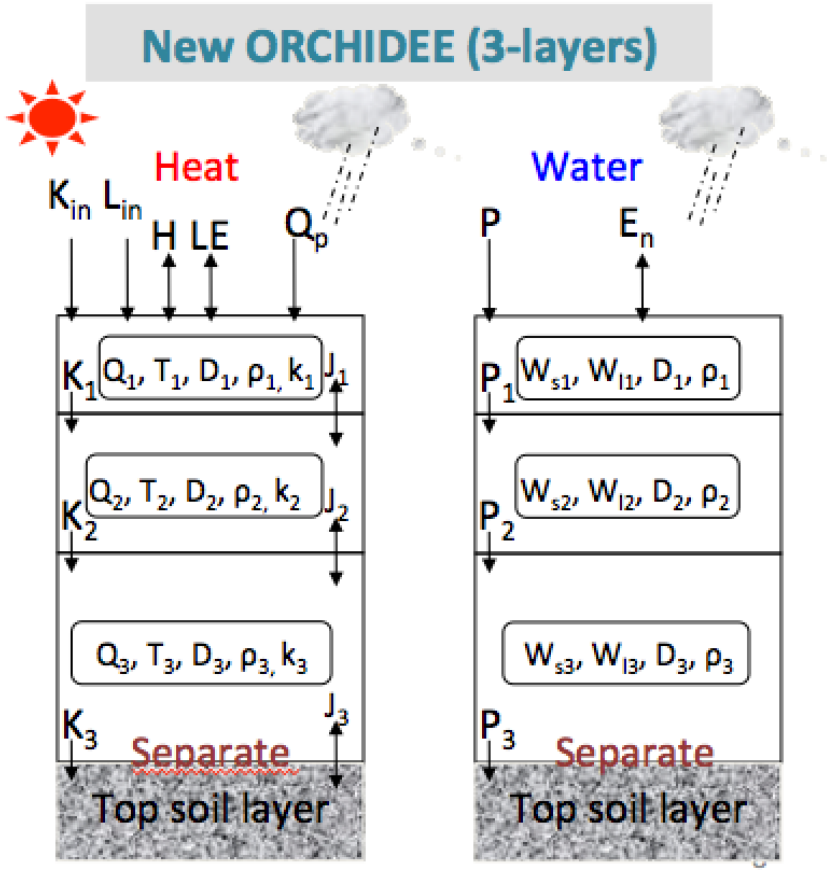


Institut Pierre Simon Laplace

Thank you for your attention

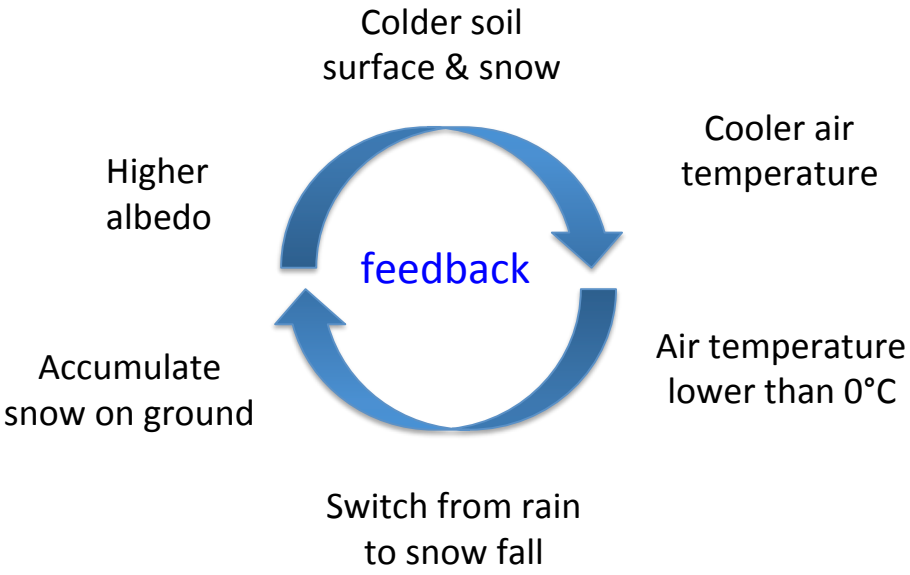
Multi-layer snow scheme

- 3 layers scheme to improve:
  - Snow dynamic (spring)
  - Snow – vegetation interactions (Shrub, grass, ..)

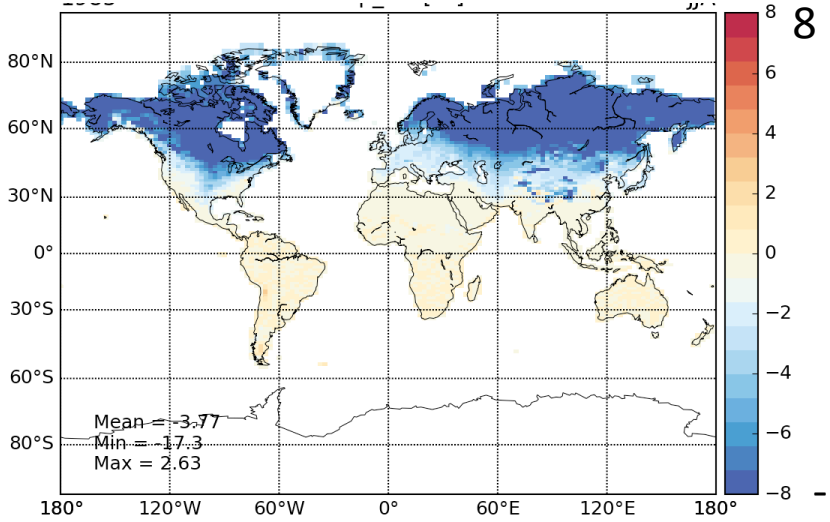


Soil freezing scheme

- Increase winter soil/air temp. (≈ 1°C)
- decrease summer soil/air temp.
- increase snow fall
- Highly sensitive to surface heat conductivity



Standard soil conductivity



Delta Surface Temperature (summer, °K):

'freezing' minus 'no freezing'

- 8

decrease conductivity for upper 10 cm