Accounting for grassland management into a terrestrial ecosystem model

Model description
and evaluation at 11 European sites

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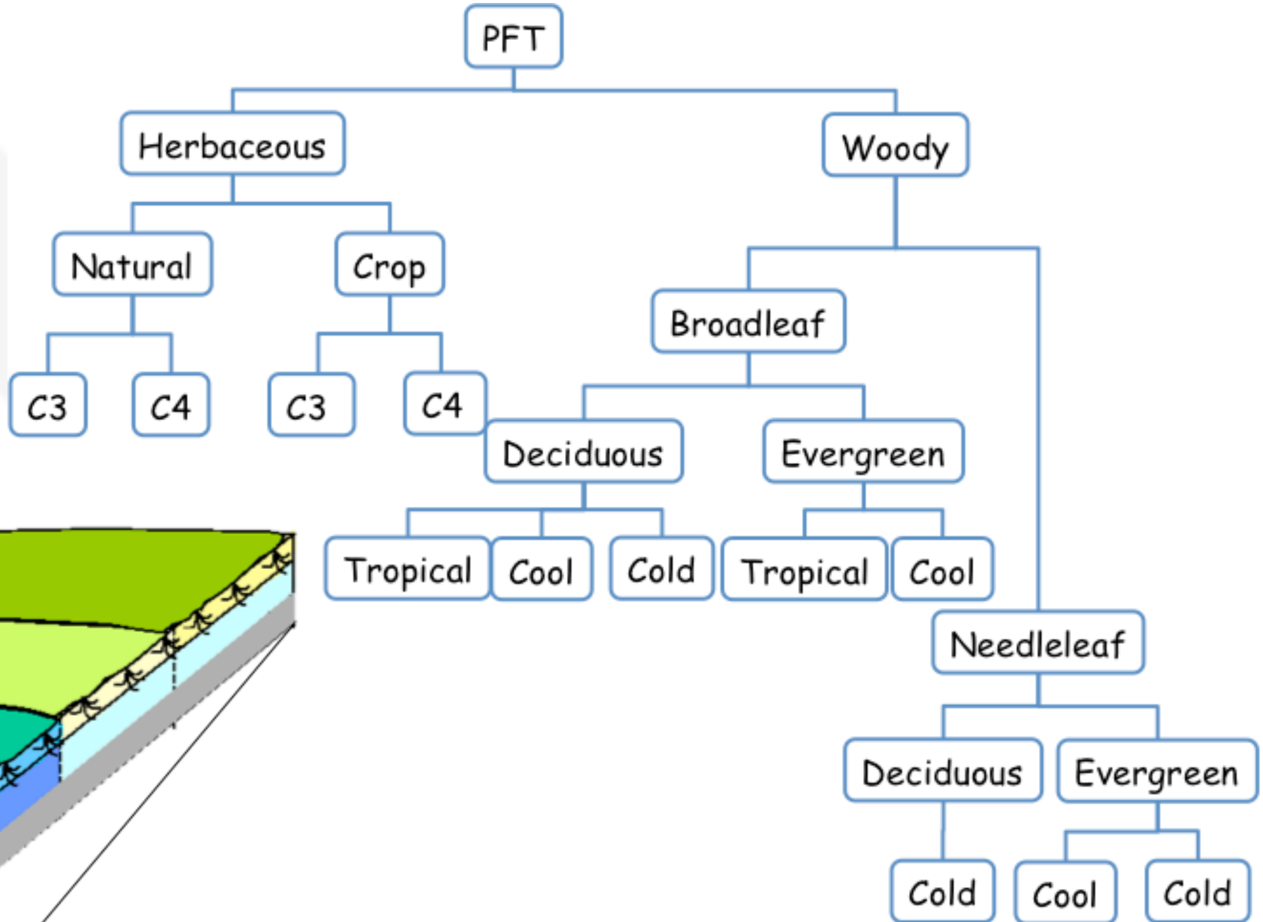
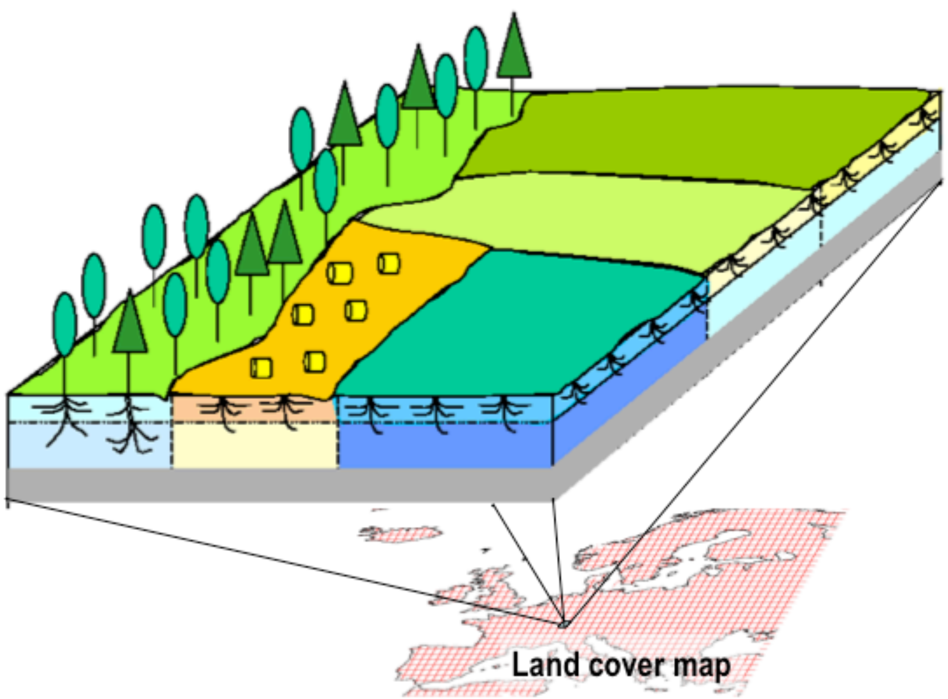
Context

- 20% of the world's land surface covered by grasslands
- Large grassland areas are managed
  - Grazed or cut for feeding animals
- Grassland management
  - impacts on
    - The seasonal cycle of the vegetation
    - The Carbon cycle (extra lateral fluxes)
  - Induces methane emissions by the ruminants

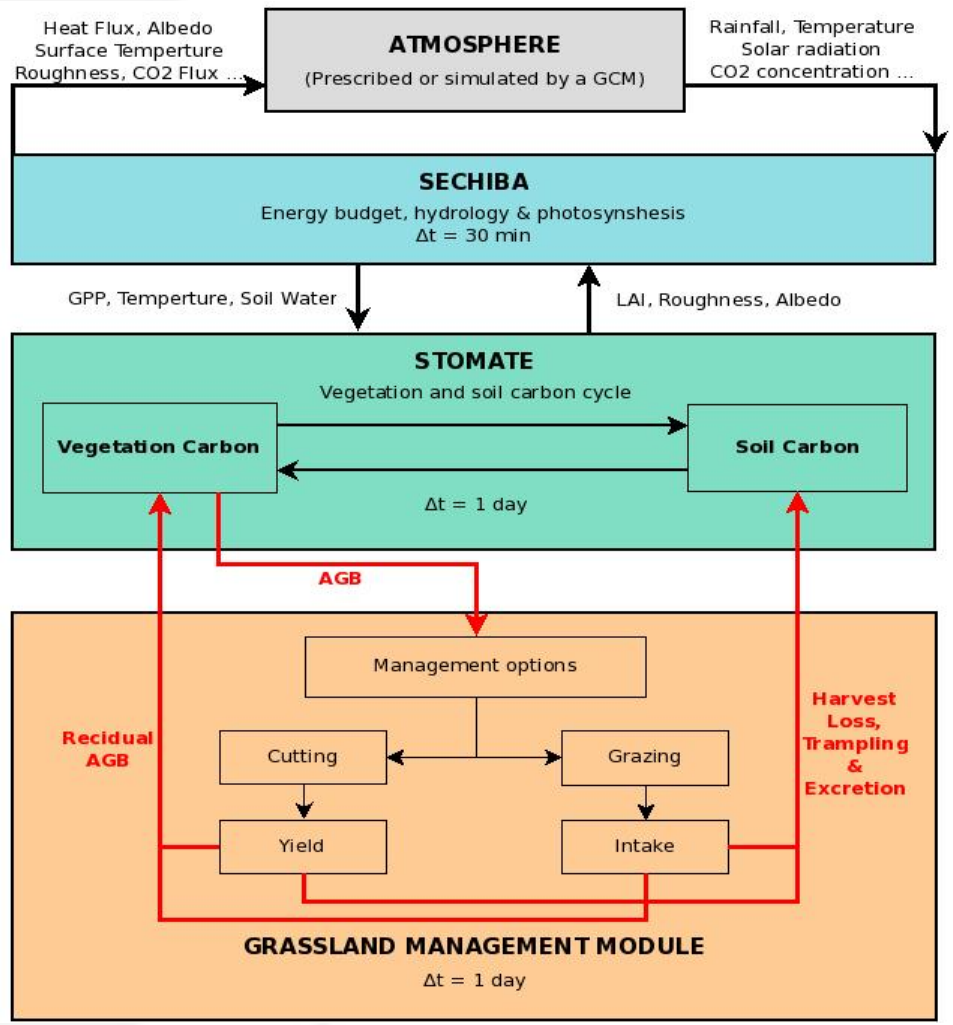
Vegetation modelling into ORCHIDEE





Model’s structure

ORCHIDEE-GM (Grassland Management)



Effects of the management

At each cutting operation,

• A fraction of the shoot biomass is harvested and exported away from the grassland (Forage Yield)

• A fixed amount corresponding to the residual shoot dry matter (DM) (e.g. 0.1 kg DM m-2) is left in field

• A certain amount (e.g. 5%) of the grass harvest is lost as litter.

During grazing,

• Animal herbage intake, milk production (MP), returns (manure), respiration and CH4 emissions are simulated.

• The detrimental effect of trampling on herbage (e.g. 0.8% of residual shoot biomass return as litter with 1 LSU/ha).

Other modifications within ORCHIDEE

1) Reduction of leaf fraction in total AGB after harvest (cut):
a leaf fraction of 10% and a stem fraction of 90% in remaining

2) Translocation from carbohydrate reserves after harvest (cut)

3) Age-related SLA: sla_1 equals to SLA_{max}, then 0.90, 0.85 and 0.80 of SLA_{max} is the SLA for age class 2, 3 and 4, respectively.

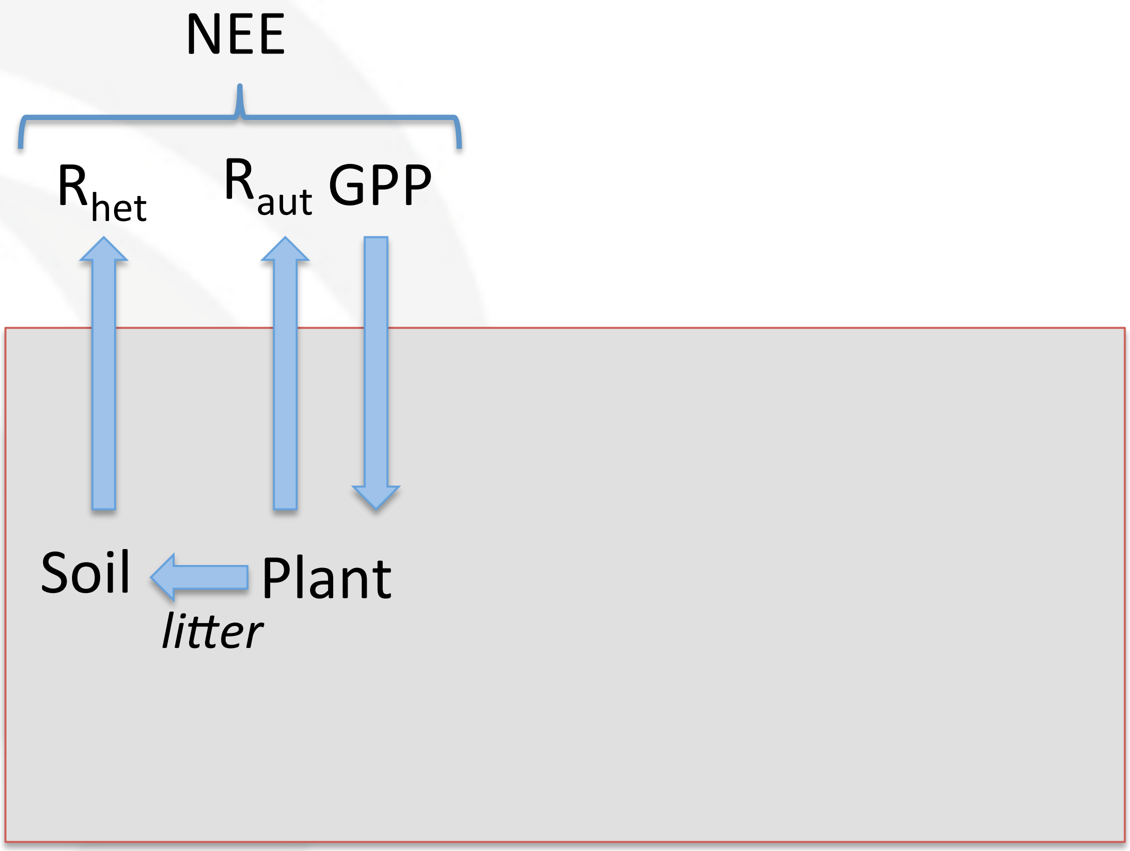
$$SLA = \sum_{i=1}^{4} sla_i \times f_i$$

4) Shading effect:
AGB Turnover as a function of LAI
turnover_time τ (days)

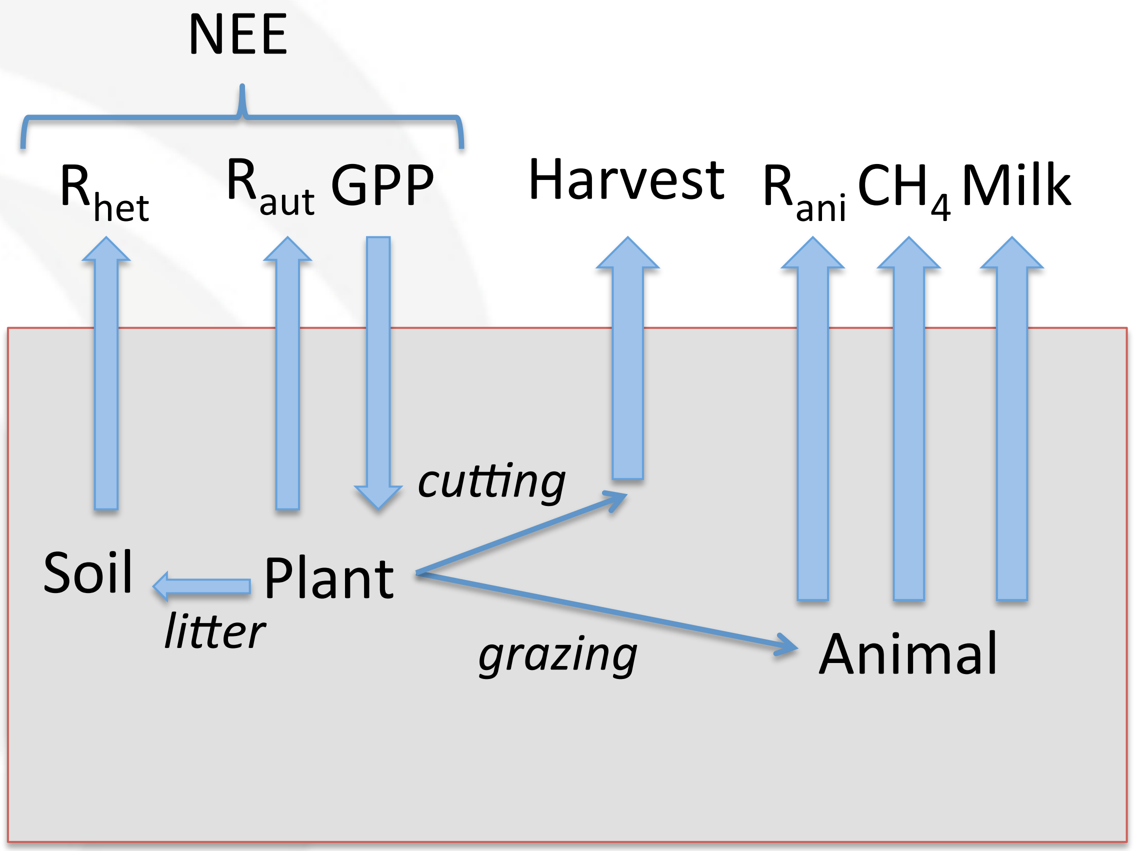
$$\tau = \max(\tau_{min}, \tau_{max} - LAI \times 10)$$

with τ_{min} = 45 days and τ_{max} = 85 days

Management-induced lateral C fluxes

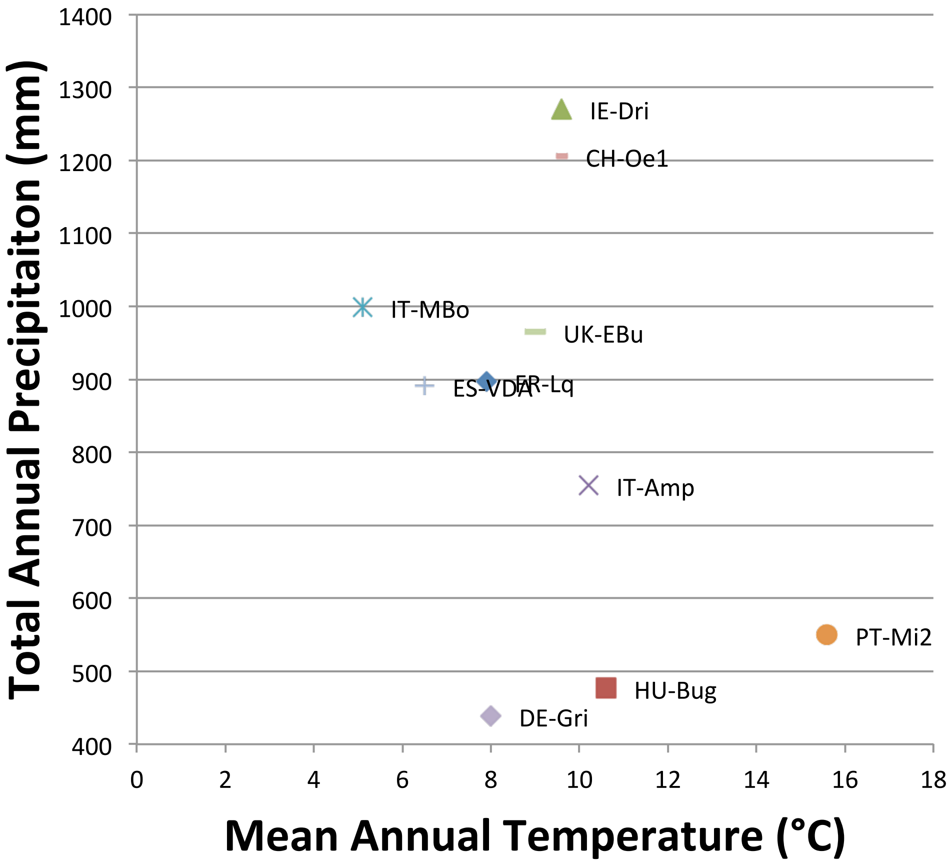


Management-induced lateral C fluxes

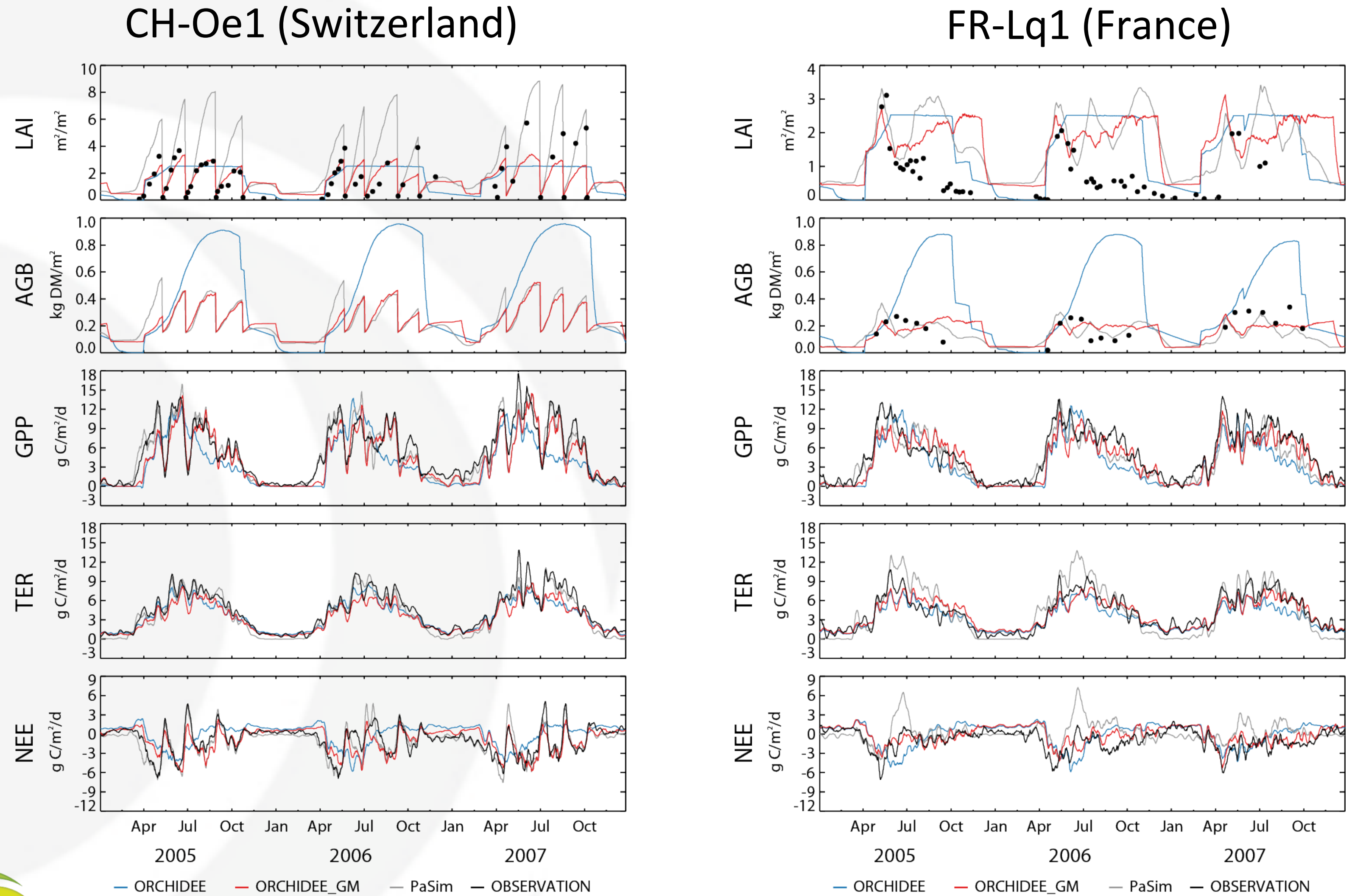


In-situ data

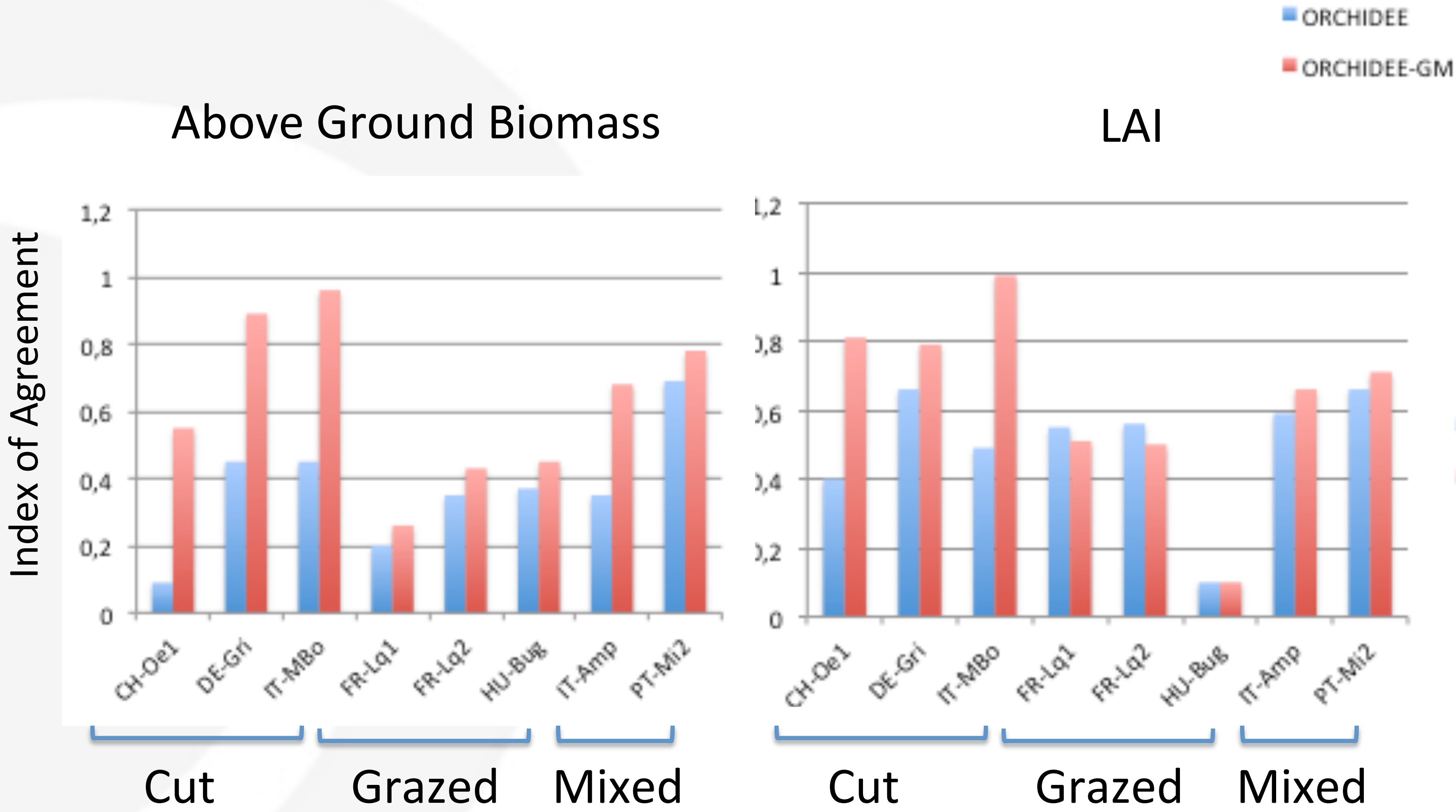
- From Carbo-Europe database
- @ 11 European sites
- Available variables
  - C fluxes : NEE, GPP, TER
  - Ancillary data :
    - above biomass
    - LAI



Model performance example

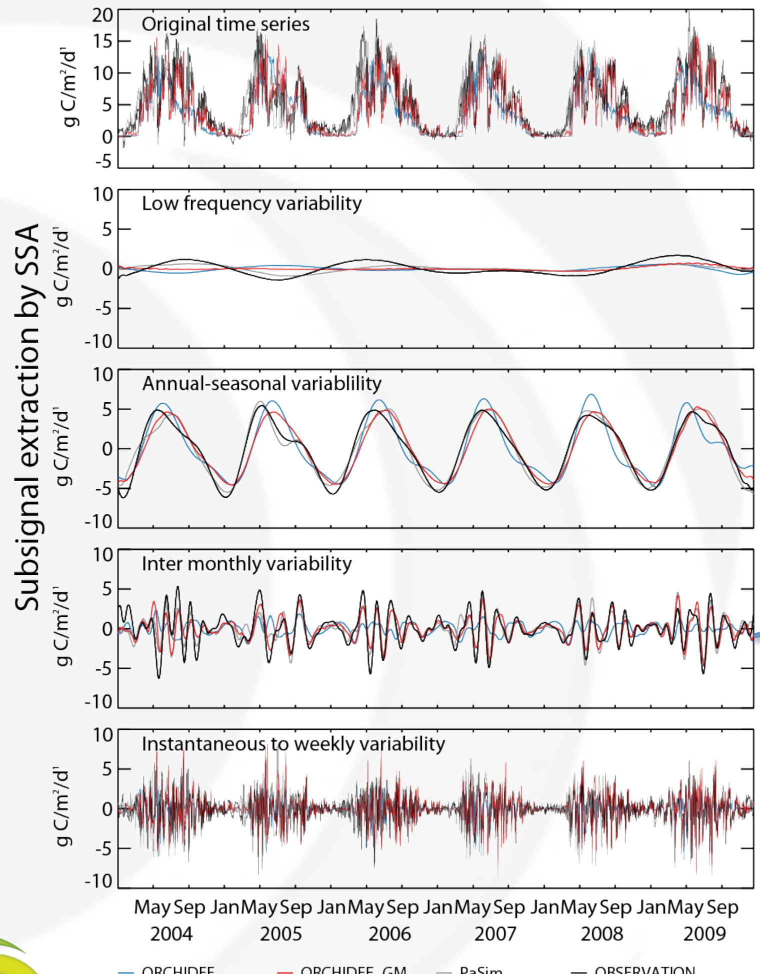


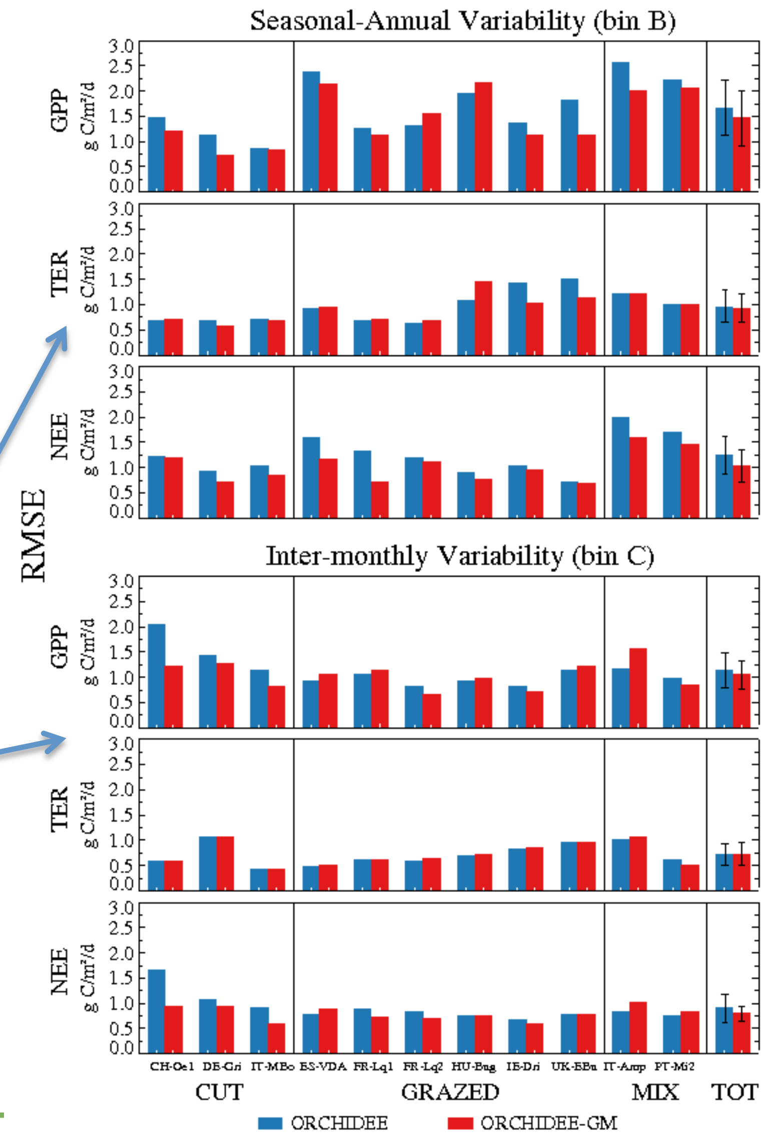
Model performance on biomass



Model performance on CO_2 fluxes

Subsignals extracted by **Singular System Analysis (SSA)**





Automatic management module

- Defines animal density and fraction of grazed vs cut grasslands in order to maximize livestock production

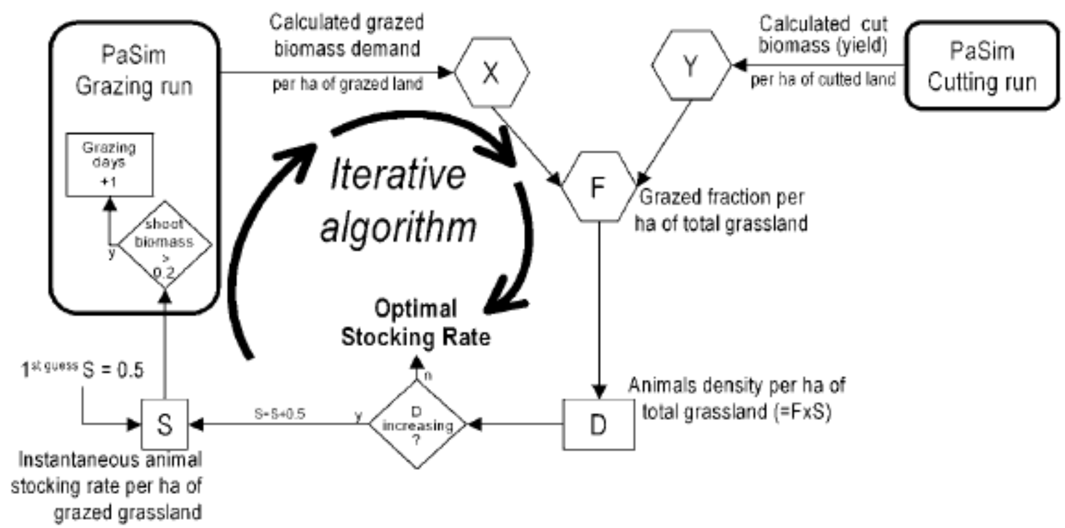
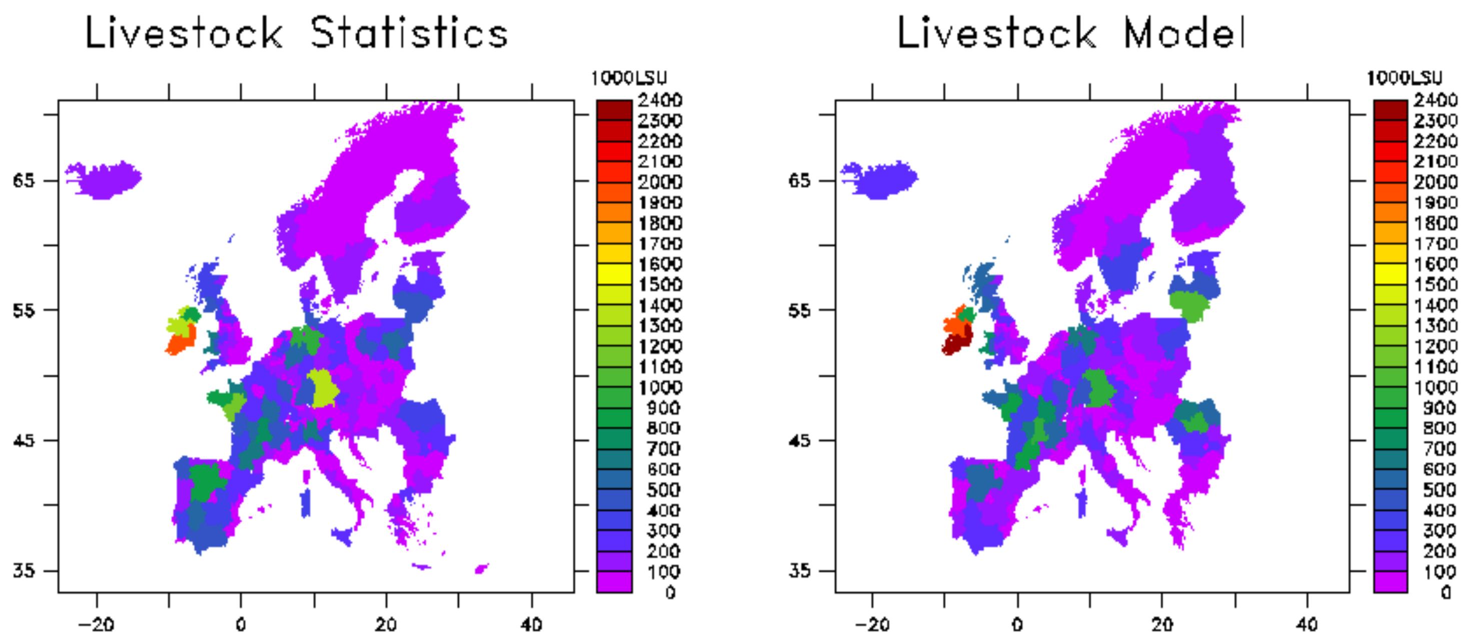


Figure 1. Diagram of the optimization procedure used for defining optimal animal stocking rate and optimal proportion of grazed grasslands.

from Vuichard et al., 2007

New diagnostic variable

- Livestock production



Chang et al., in prep.

Summary

Development of a new module accounting for grassland management

- Better representation of the C fluxes within the ecosystem
- Slight improvements of the fit to data on monthly to yearly timescales
- Livestock production is a new diagnostic variable of our model