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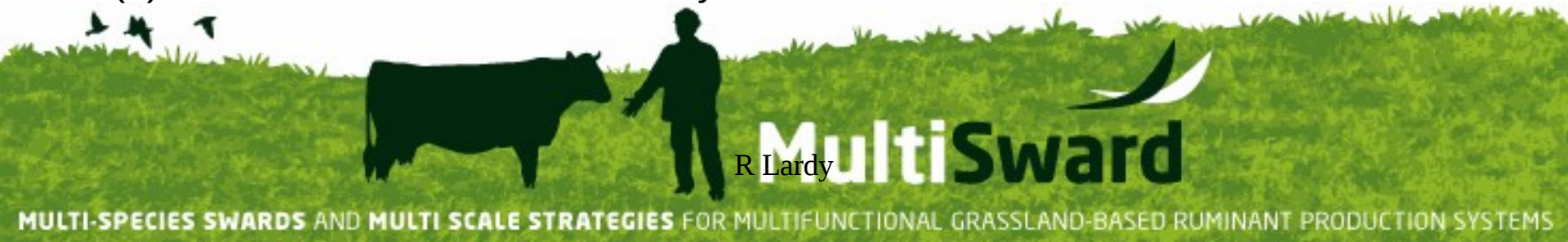
Pasture Simulation model (PaSim)

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Climate

- Radiation
- Precipitation
- Temperature
- Water Vapour pressure
- Wind speed
- CO₂
- NH₃

Soil

- Texture
- SWC
- Conductivity
- Density
- Depth

Vegetation

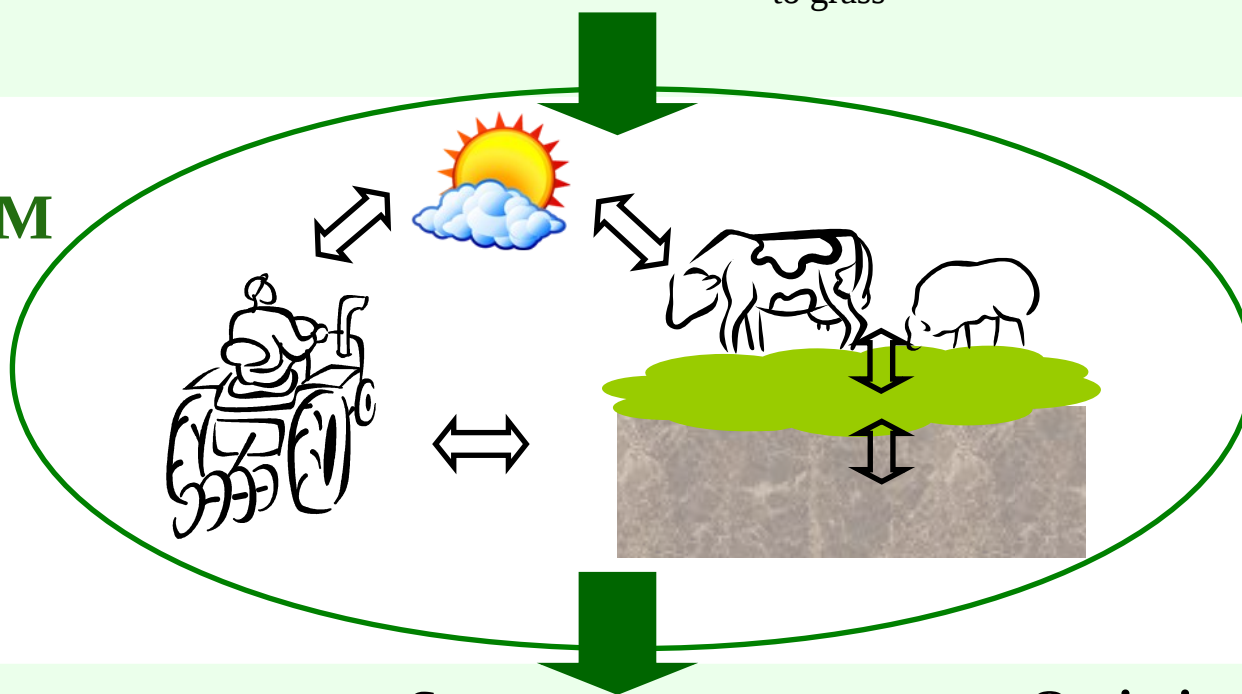
- Multi or monospecies
- With or without legumes

Herbivores

- Type (heifers, suckler or dairy cows, sheep)
- LW, BCS, age, MP_{pot,max} at turnout to grass

Management

- Mowing
- N fertilization
- Grazing
- Tillage

PASIM**Fluxes**

- GHG (CO₂, N₂O, CH₄)
- C, N, H₂O & energy fluxes ...

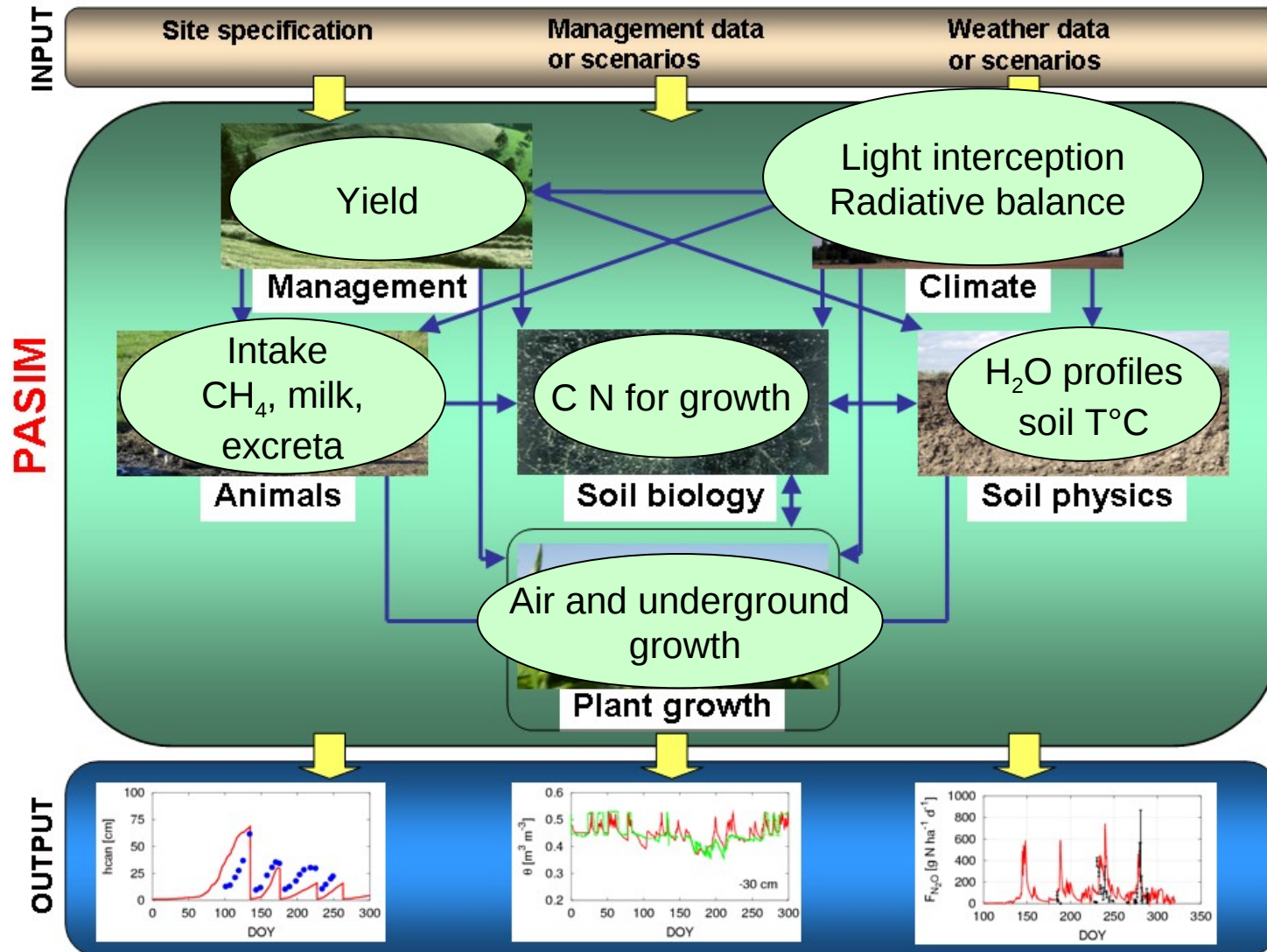
States

- Forage provision
- MP, LW and BCS
- SOM
- SWC ...

Optimized management

- Mowing
- N fertilization
- Grazing
- Irrigation

PaSim model

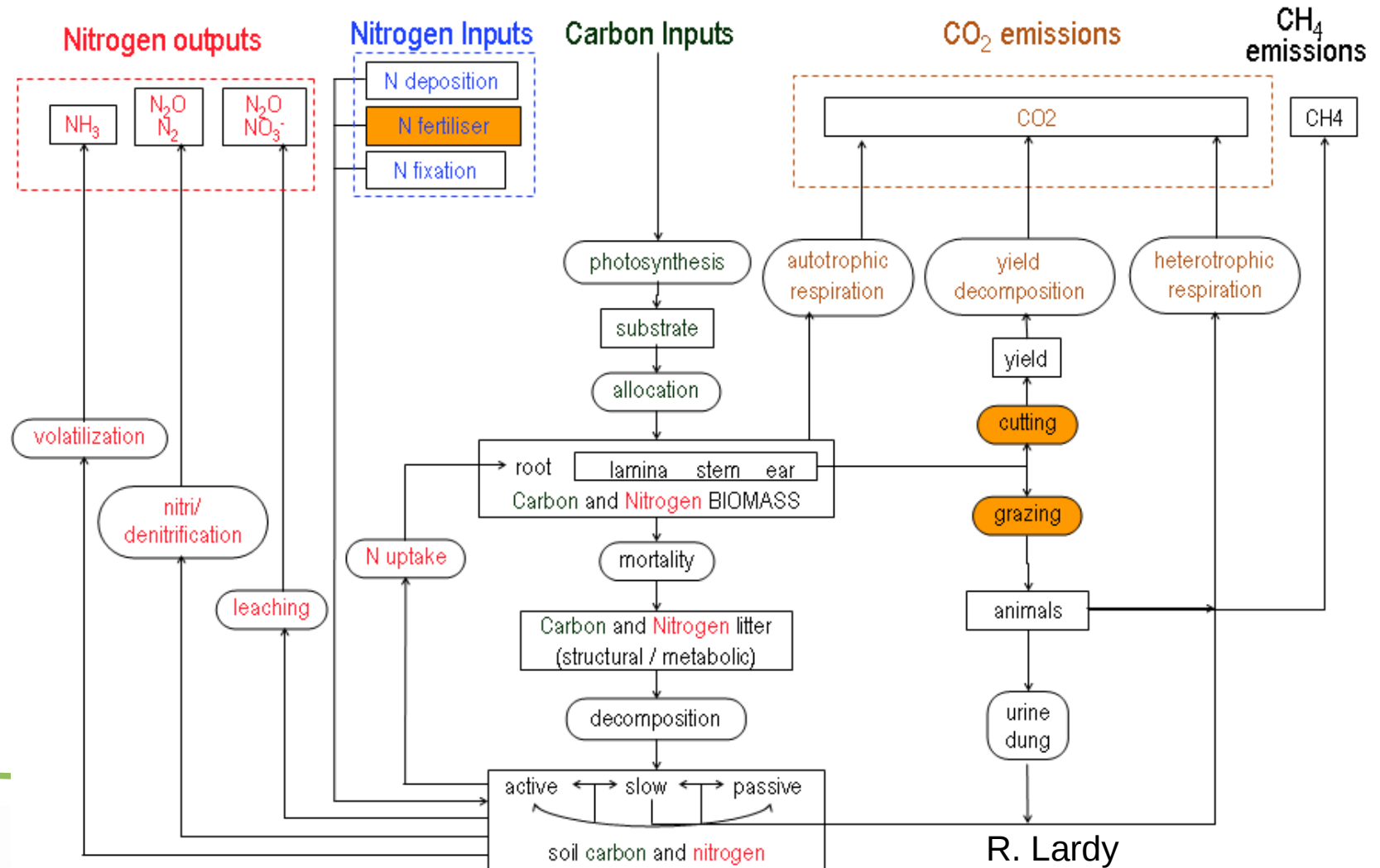


History

- 1st version [Riedo et al., 1998] of PaSim based on Hurley Pasture Model [Thornley, 1998]
- N cycle improvement [Schmid et al., 2001]
- Grazing improvement [Vuichard et al., 2007]
- New animal modules [Graux et al., 2010]

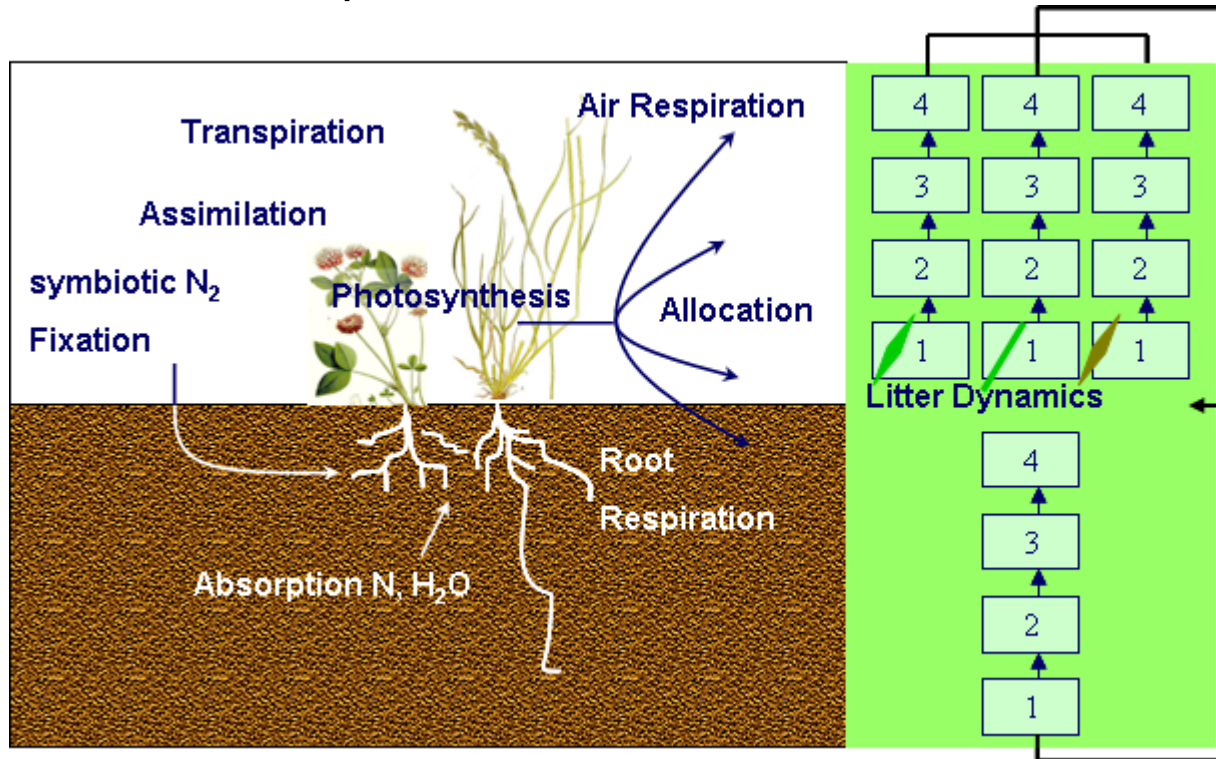
PaSim C&N model

(Thornley et al., 1998; Riedo et al., 1998)



PaSim – Vegetation

- Initially developed for productive permanent grassland, with 2 main species: *Lolium perenne* & *Trifolium repens*
- Plot-scale model
- Vegetation model and not species model, only 2 functional groups: grass and legume (initially constant fraction)
- Plant components : lam, sheath and stem, ear, root (4 age categories)



R. Lardy
Meeting on grass growth
modelling, 9th February

Soil processes in PaSim

Module structure from CENTURY model
(Parton et al. 1987)

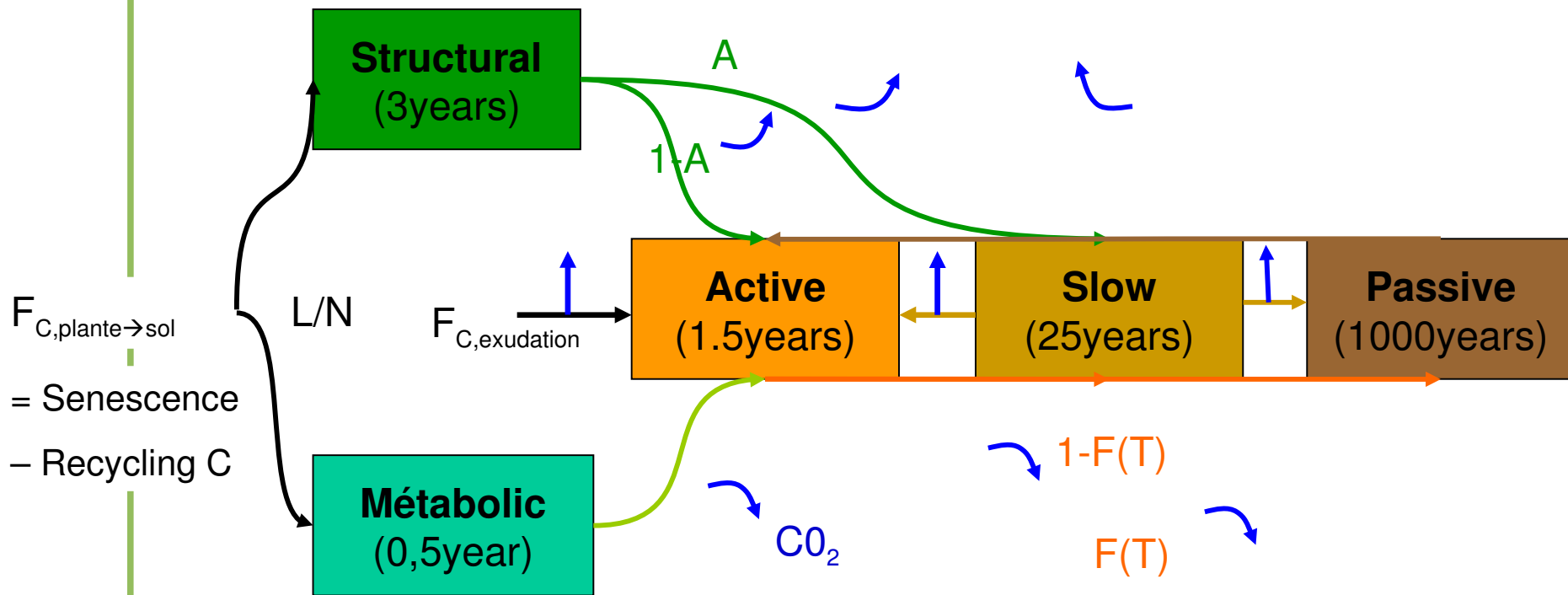
Processes:

- Decomposition of plant residues (litter)
 - ↳ Carbon fluxes and respiration
 - ↳ Nitrogen mineralisation, nitrification and denitrification
- Physical processes: distribution of water in horizons

5 soil pools of C & N:

- Metabolic and structural tanks (litter)
- Active, slow and passive tanks

Flow Chart C exchanged between the 5 compartments of the module decomposition of the Dry Organic Matter



$$F_{C, dec} = k_{dec, \theta} \times k_{dec, T} \times k_{dec, i} \times W_{C, i}$$

$\times k_{dec, text}$

T : content of clay & silt

A : Fraction of lignin

L/N : lignin ratio on nitrogen

Minimum PaSim inputs

Meteo: precipitations, air temperature, wind speed, radiation, relative humidity

Management: cutting dates, fertilization dates + amount and type, grazing dates + stocking density + animal type

Site information: latitude, slope, aspect, altitude

Soil: depth, bulk density, texture (clay, silt, sand), pH

Simulated grassland sites (Carboeurope/Nitroeurope)

Site	Cut/ Graz	Nfert (kg N ha ⁻¹)	2002	2003	2004	2005	2006	2007	2008	2009
CH-Oens	C	171	x	x	x	x	x	x	x	x
DE-Grillenbug	C	-			x	x	x	x	x	
ES-VDA	G	-			x	x	x	x	x	
F-Laq-ext	G	-	x	x	x	x	x	x	x	x
F-Laq-int	G	190	x	x	x	x	x	x	x	x
HU-Bug	G	-					x	x	x	x
IE-Carlow	C,G	200			x	x	x			
IE-Dripsey	G	306		x	x	x				
IT-Amperlo	C,G	-		x	x	x	x	x		
IT-MtBondone	C	-		x	x	x	x	x		
NL-Cabauw *	G	52			x	x	x	x		
PT-Mitra	G	-				x	x	x		
UK-Easterbush N	G	172	x	x	x	x	x	x	x	
UK-Easterbush S	G	172	x	x	x	x	x	x	x	
Σ 13 sites			year x site = 74							

Use of PaSim

French project :

- ANR CLIMATOR (2007-2010)
- ANR VALIDATE (2008-2011)
- ANR EPAD (2010-2013)

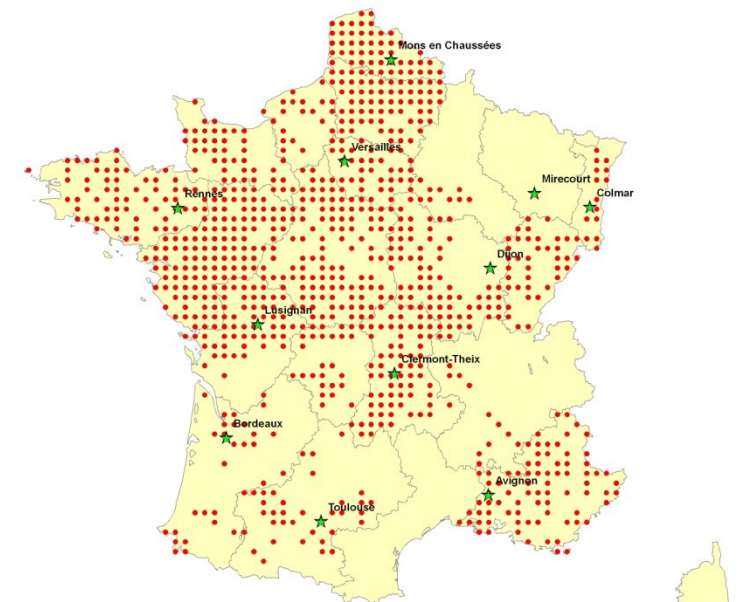
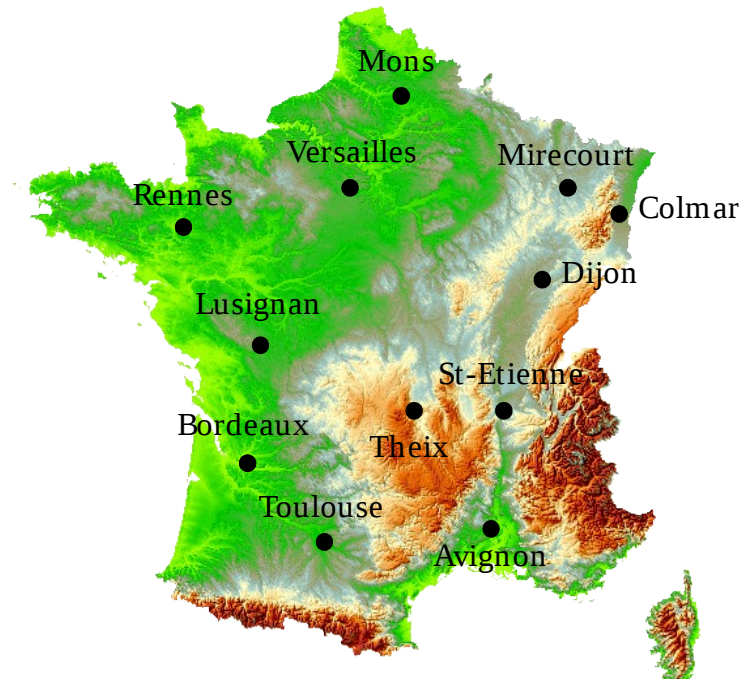
European Project

- AnimalChange (2011-2014)
- NitroEurope (2006-2010)
- CarboExtreme (2010-2013)
- CarboEurope (2004-2008)
- GHG Europe (2010-2013)

– ...

CLIMATOR PROJECT

- Goals :
 - “Develop reference tools to analyse vulnerability of agroecosystems to climate change”
- Configuration of simulations
 - 12 Stations
 - 3 Soils (INFOSOL) :
 - 1 common soil to all stations
 - 2 specific soils of pasture
 - 12 climatic scenarios



A.I. GRAUX PhD

Graux et al., Ensemble modelling of climate change risks and opportunities for managed grasslands in France. Agric. Forest Meteorol. (in preparation)

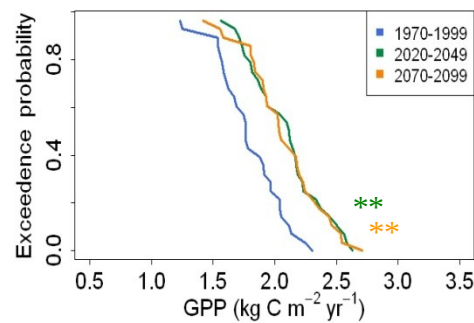
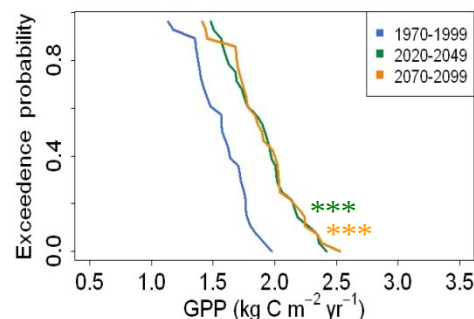
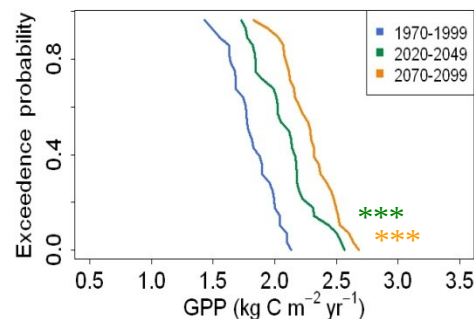
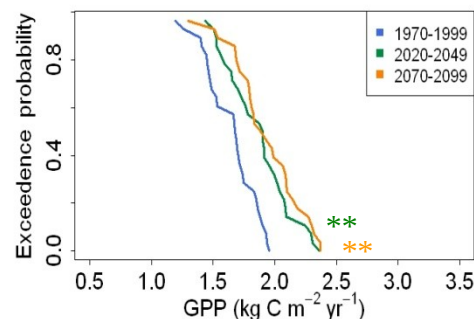
Sown

Sown Irrigated

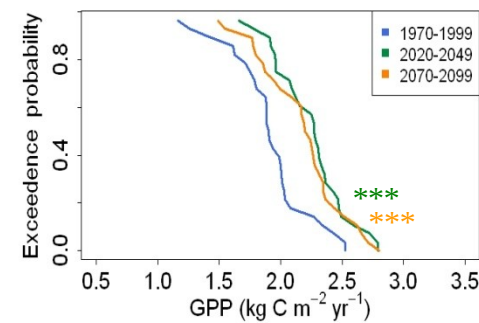
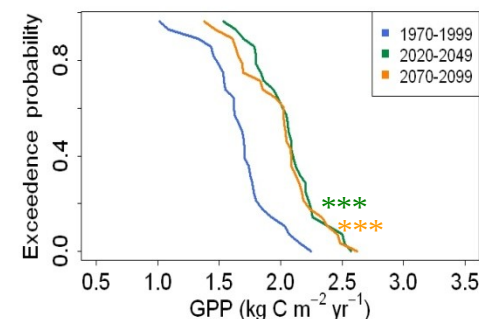
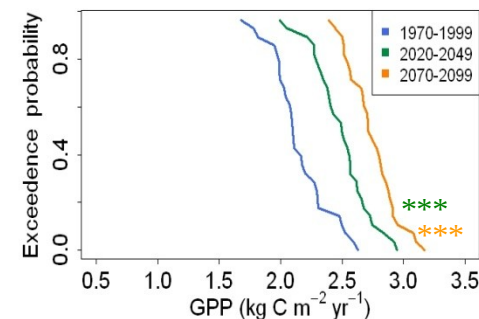
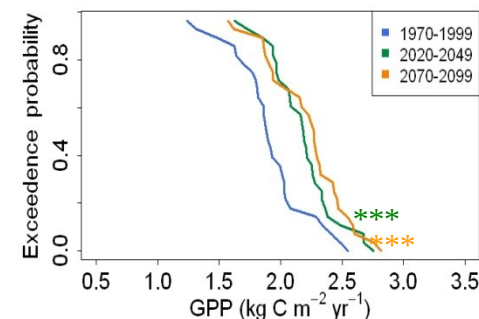
Permanent Extensive

Permanent Intensive

MIRECOURT



AVIGNON



Upscaling Climate Change Projections (ANR VALIDATE)

8*8 km France (CERFACS: ‘statistical disaggregation method for downscaling climate scenarios’)

Soil (meshed)

Regionalised (gridded) mineral and organic N fertilisation

- Distinguishing temporary pasture, intensive and ‘rough grazing’ permanent pasture

Upscaling: France, if possible Europe



Theix (VALIDATE) experimentation

Permanent grassland (French Massif Central, lat 45°43'N, lon 03°01', Alt 870m)

Treatment : 8 combinations (4 repetitions)

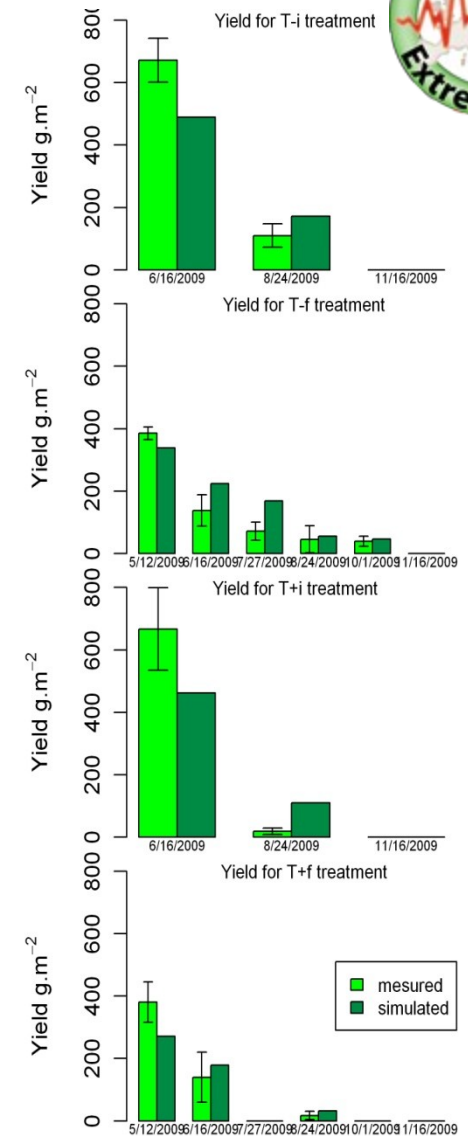
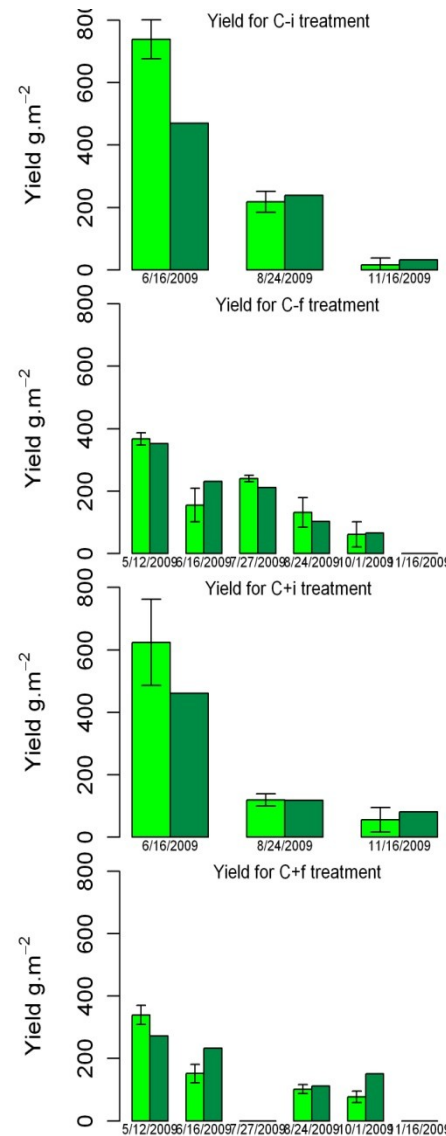
- Control (C), Air warming (T) with precipitation reduction
- Extreme Event (X) or not (N)
- High cut frequency (F), lower cut frequency (I)

Air warming carried out thanks to night passive warming system

Extreme event produced by active warming system

Theix (VALIDATE) experimentation

Model Data Fusion (Bayesian calibration)



Main PaSim publications

- Graux, A.-I., Gaurut, M., Agabriel, J., Baumont, R., Delagarde, R., Delaby, L. and Soussana, J.-F., 2010. Development of the Pasture Simulation Model for assessing livestock production under climate change. *Agriculture, Ecosystems and Environment* (in revision).
- Riedo, M., Grub, A., Rosset, M., Fuhrer, J., 1998. A pasture simulation model for dry matter production and fluxes of carbon, nitrogen, water and energy. *Ecol. Model.* 105, 41–183.
- Schmid, M., Neftel, A., Riedo, M., Fuhrer, J., 2001. Process-based modelling of nitrous oxide emissions from different nitrogen sources in mown grassland. *Nutr. Cycl. Agroecosys.* 60, 177–187.
- Vuichard, N., Ciais, P., Viovy, N., Calanca, P., Soussana, J.-F., 2007b. Estimating the greenhouse gas fluxes of European grasslands with a process-based model: 2. Simulations at the continental level. *Global Biogeochem. Cy.* 21, GB1005,1-GB1005.13.