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# Plant trait-based assessment of the Pasture Simulation model

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# Ecosystem services and grasslands

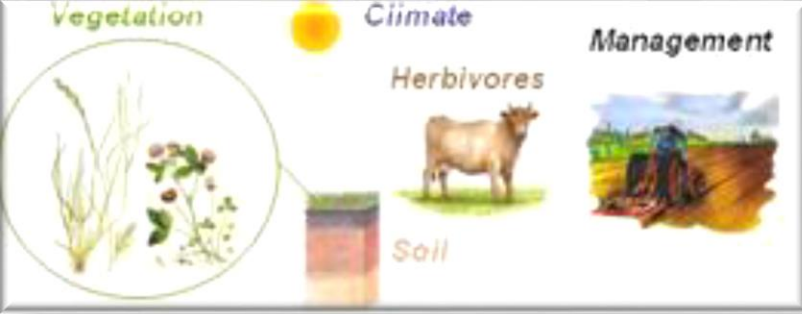
Mainstay of the livestock and dairy industry as a key component in the production of high-quality animal product

Sizeable share of soil C stock - soil community structures play a vital role in nutrient cycling for plant uptake

High diversity in flora and fauna (value for nature conservation)



Disentangling the relationships between structure and functioning of grasslands may provide answers of direct relevance to farm managers and policy-makers about the risk presented by a reorganisation of local biodiversity and production potential



# Grassland modelling

Inputs  
(climate, soil, management)

**Pasture Simulation model  
(PaSim)**

Initial values

Parameters

Production



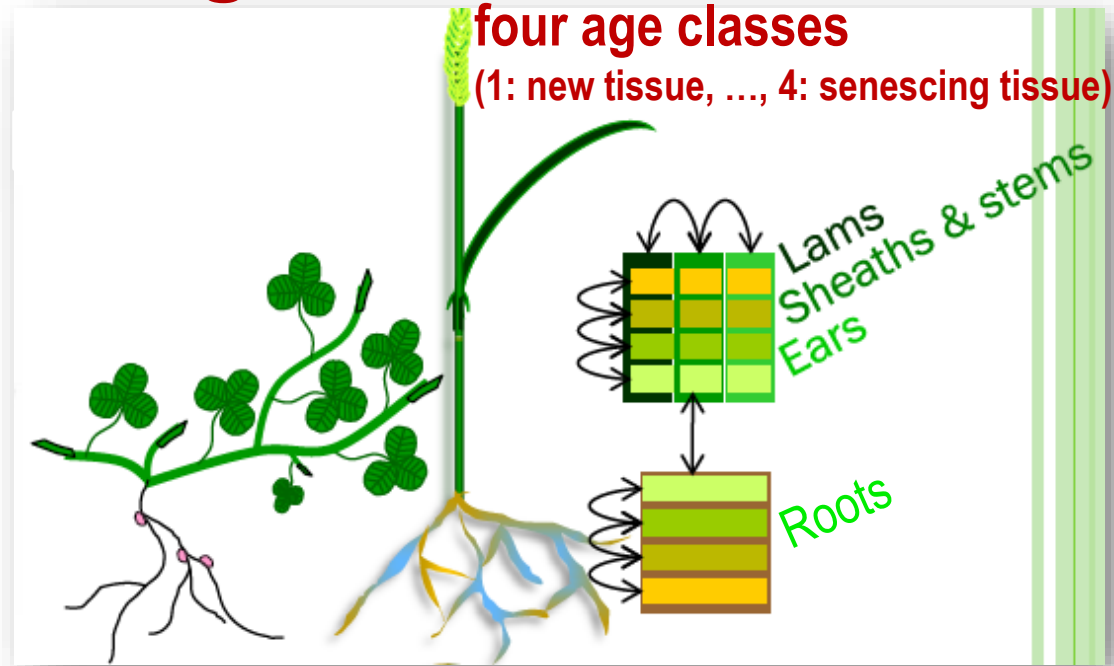
Biophysics

Biogeochemistry

Outputs

(forage yield, animal intake, milk production, soil water content, soil temperature, gross primary productivity, ecosystem respiration, net ecosystem exchange, N<sub>2</sub>O emissions, CH<sub>4</sub> emissions, etc.)

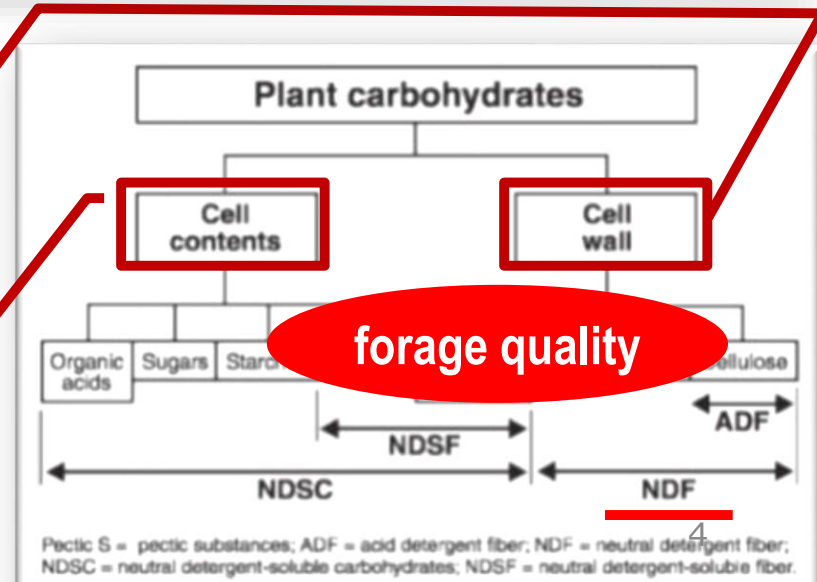
# Vegetation sub-model



Plant is described by its biomass, leaf area index, carbon and nitrogen cycles

Plant carbon is divided into:

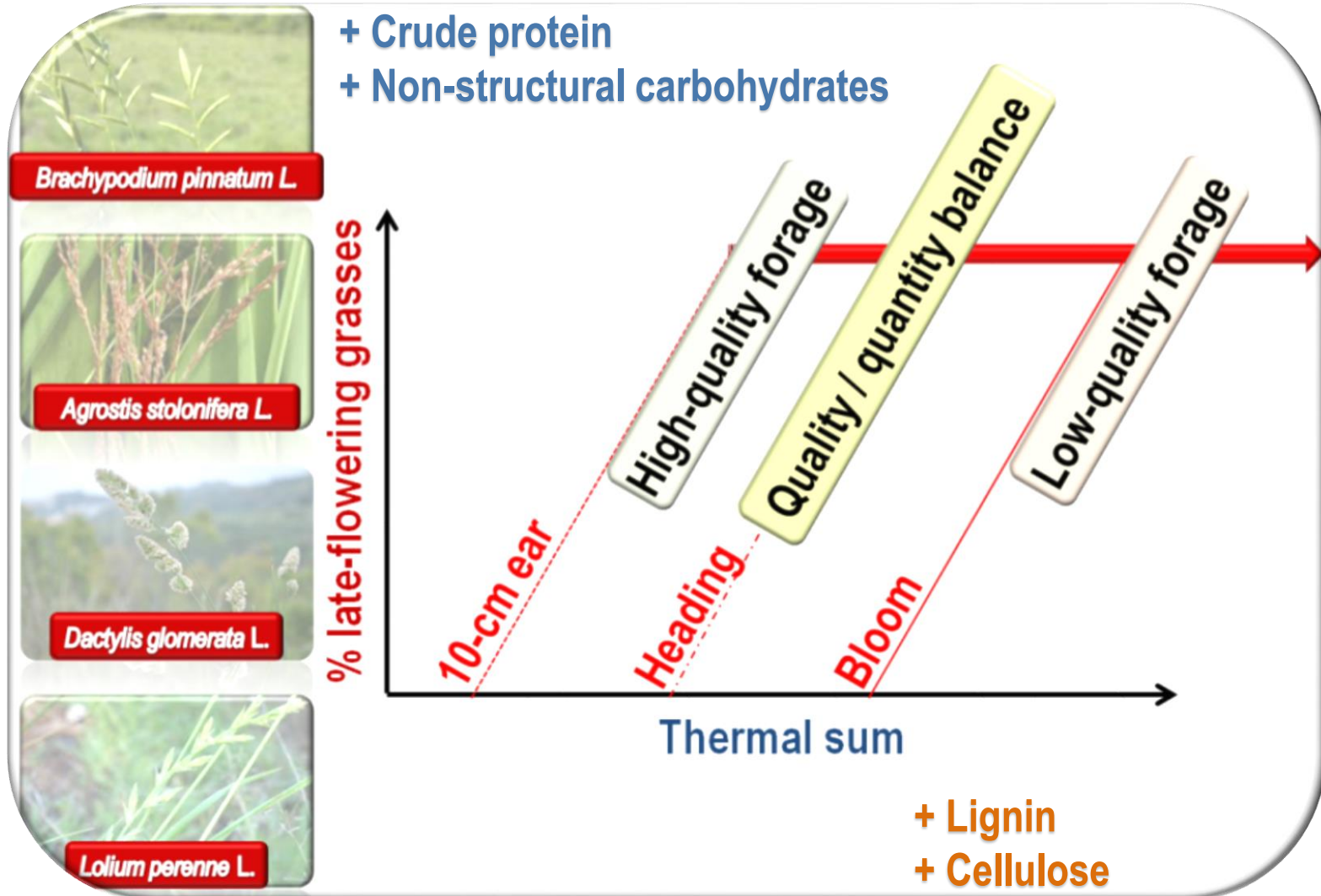
- structural carbon
- substrate carbon











# Forage quality

- Lignin
- Cellulose
- + Crude protein
- + Non-structural carbohydrates



- + Lignin
- + Cellulose
- Crude protein
- Non-structural carbohydrates

# Functional types (A, B, b, C, D, d)

Functional type	A, B	b	C
Grassland productivity	Strong	Quite strong	Weak
Fertility and soil depth	High, deep soil	Intermediate	Low, shallow soil
Precocity	Very early to early	Late	Quite early
Full heading	800-1000 °C-d	1400 °C	1100 °C
Leaf type	Medium to large	Medium	Delicate
Cover type	"Powerful tuft"	"Medium carpet"	"Short and dense carpet"
Dominant grasses	Ryegrass, orchard grasses, tall fescue, tufted grass, etc. 	Bentgrass, timothy, oatgrass, Kentucky bluegrass 	Red fescue, sheep fescue, quaking-grass, crested dog's-tail 
Legumes	White clover, red clover 	- 	Lotus, black medick 
Various dominating	Dandelion, rumex, umbelliferæ	Centaureas	<i>Achillea millefolium</i> L., mouse-ear hawkweed

# Parameterization: C and N concentrations

Parameter (calibration-based: Ma et al., 2015)	Unit	Value
Fractional C content of shoot structural dry matter ( $f_{C,sh}$ )	kg C kg <sup>-1</sup> DM	0.435
Fractional C content of root structural dry matter ( $f_{C,rt}$ )	kg C kg <sup>-1</sup> DM	0.430
Maximum plant N concentration ( $F_{N,max}$ )	kg N kg <sup>-1</sup> DM	0.030
Parameter of the fractional N content of new plant structural dry matter ( $f_{N,ref}$ )	kg N kg <sup>-1</sup> DM	0.018

Type	$f_{C,sh}$	$f_{C,rt}$	$F_{N,max}$	$f_{N,ref}$
A	0.446	0.426	0.036	0.0176
B	0.449	0.429	0.029	0.0142
b	0.452	0.432	0.034	0.0166
C	0.455	0.435	0.035	0.0171
D	0.462	0.442	0.030	0.0147
d	0.462	0.442	0.034	0.0166

$f_{C,sh}$  and  $f_{n,ref}$  estimated from the leaf C and N content of 38 plant species studied by Cruz et al. (2010)

Assumptions of linear relationships:  $f_{C,rt} = 1.28 \cdot f_{C,sh}$   
 $F_{N,max} = 0.20 f_{N,ref}$





**Grassland typologies in the  
Massif Central of France**





# Diagnostic prairial

en zones fromagères AOP du Massif central

## OUTIL 1

### Typologie multifonctionnelle des prairies

#### Niveau 2

Version complète décrivant  
les 60 types de prairies  
identifiés en zones AOP



# Mode of exploitation



# Water status

# Fertility status

# Level of fertility



# Mode of exploitation

## Set the mode of exploitation:

- |                                                                                                                                                                    |     |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| <ul style="list-style-type: none"><li>• <u>grazed grassland</u> with possibility of mowing, irregularly occurring<br/>in case of grass overflow: grazing</li></ul> | ... |
| <ul style="list-style-type: none"><li>• <u>mown grassland</u>, at least once a year: mowing</li></ul>                                                              | ... |

# Water status

## Set the water status:

<ul style="list-style-type: none"><li>• Grassland soil with high load-bearing capacity</li></ul>	...
<ul style="list-style-type: none"><li>• Soil is always carrying, drying in summer and healthy in winter (often sloped and/or exposed to south)</li></ul>	<u>Dry soil</u> ...
<ul style="list-style-type: none"><li>• Soil is always carrying, healthy in summer and cool in winter</li></ul>	Healthy soil ...
<ul style="list-style-type: none"><li>• Soil is carrying, but can be temporarily saturated</li></ul>	Cool soil ...
<ul style="list-style-type: none"><li>• Grassland soil with bearing-capacity problems (soil moisture prevents the carrying capacity from being reached when required)</li></ul>	...
<ul style="list-style-type: none"><li>• Soil is carrying, but can be temporarily saturated</li></ul>	Cool soil ...
<ul style="list-style-type: none"><li>• Soil carrying capacity is lost during a period of time in the year owing to temporary saturation</li></ul>	Moist soil ...
<ul style="list-style-type: none"><li>• Soil is generally saturated over most of the year</li></ul>	<u>Wet soil</u> ...



# Fertility status

Set the fertility status:

a. What is the soil depth of the field?

• Shallow soil: <0.20 m, often extending in sloping lands with rock occasionally appearing on the surface	1	...
• Moderately deep soil: intermediate situation	2	...
• Deep soil: >0.60 m, often lying in the bottom of a valley or highland areas	3	...

b. What is the rate of animal returns (i.e. dejections)?

• 0	0	...
• 1 to 75 LSU·day ha <sup>-1</sup>	1	...
• 75-150 LSU·day ha <sup>-1</sup>	2	...
• >150 LSU·day ha <sup>-1</sup>	3	...

c. What is the rate of fertilization?

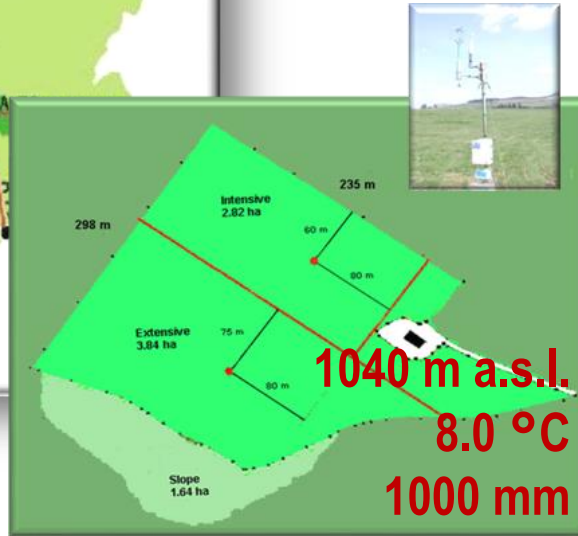
• no fertilization or very occasional mineral fertilizers or organic effluents	1	...	... (b+c)
• regular supply of manure only	2	...	
• regular supply at low rate (<60 kg ha <sup>-1</sup> ) of mineral fertilizers or liquid manure	3	...	
• regular supply at high rate (>60 kg ha <sup>-1</sup> ) of mineral fertilizers or liquid manure	4	...	

# Level of fertility

		Sum of answers to previous questions (b) and (c)						
		1	2	3	4	5	6	7
Soil depth (answer of question [a] )	1 Shallow	Very poor fertility	Very poor fertility	Poor fertility	Average fertility	Average fertility	High fertility	High fertility
	2 Moderate	Very poor fertility	Poor fertility	Average fertility	Average fertility	High fertility	High fertility	Very high fertility
	3 Deep	Poor fertility	Average fertility	High fertility	High fertility	Very high fertility	Very high fertility	Very high fertility

# Laqueuille

# Extensive



0 kg ha<sup>-1</sup> yr<sup>-1</sup>  
~0.5 LSU ha<sup>-1</sup> yr<sup>-1</sup>

→ Type b

210 kg ha<sup>-1</sup> yr<sup>-1</sup>  
~1 LSU ha<sup>-1</sup> yr<sup>-1</sup>

Grass-legume mixed sward (dominant species: *Agrostis capillaris*, *Lolium* spp., *Dactylis glomerata*, *Trisetum flavescens*, *Poa pratensis*, *Festuca rubra*, *Trifolium repens*).



→ Type B

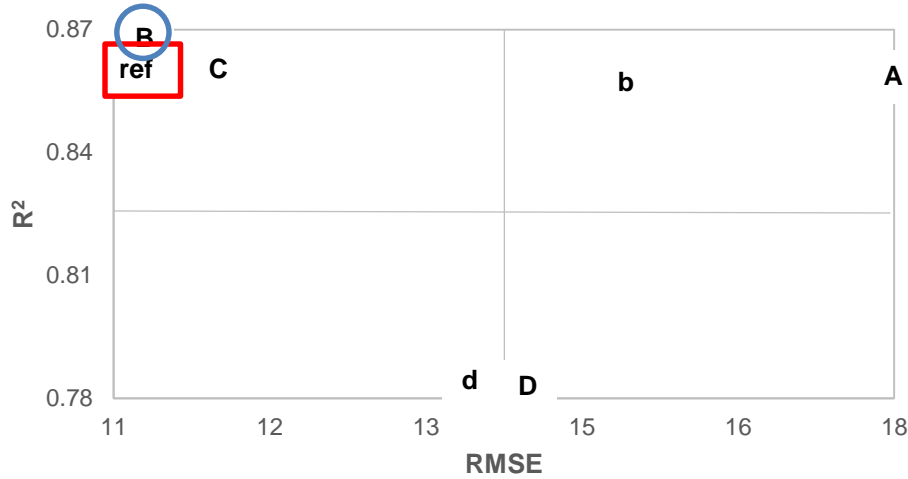


# Model evaluation / 1

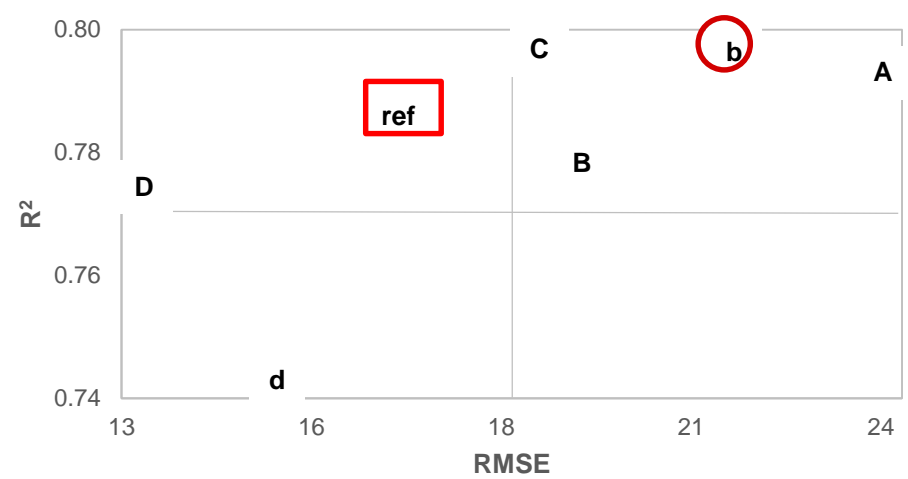
Intensive – Type B

Extensive – Type b

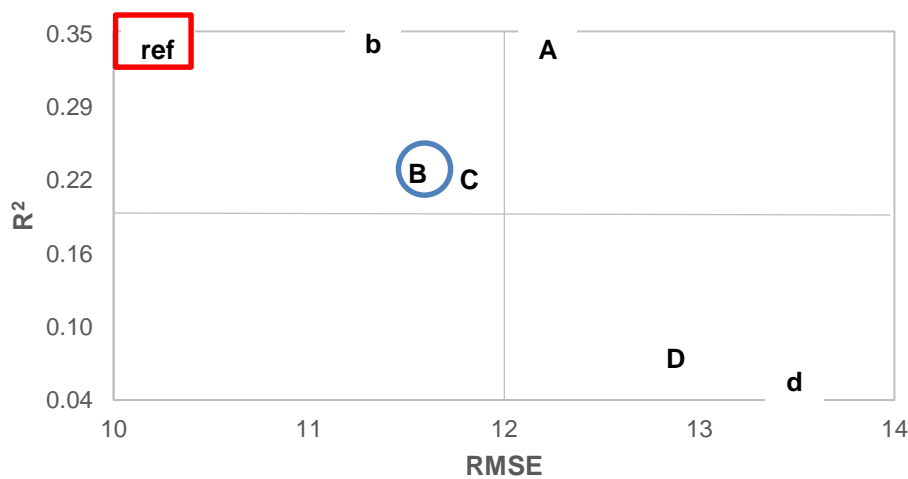
Gross primary productivity



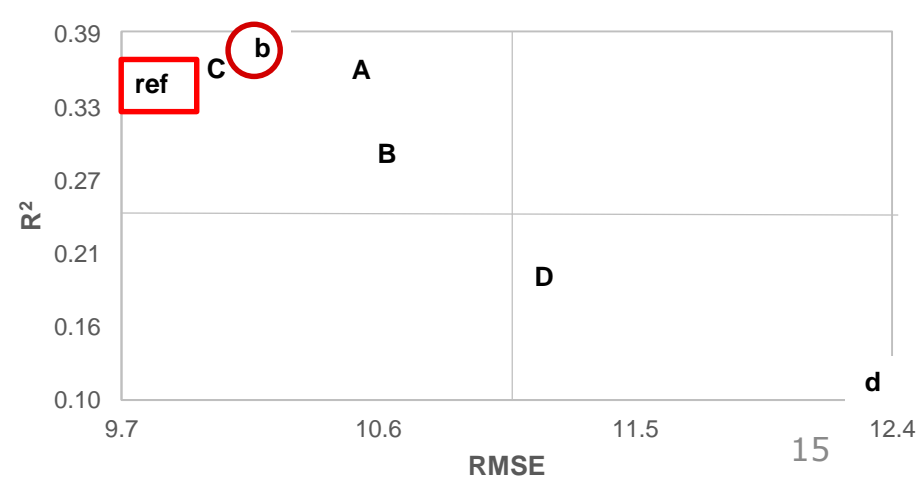
Gross primary productivity



Net ecosystem exchange



Net ecosystem exchange

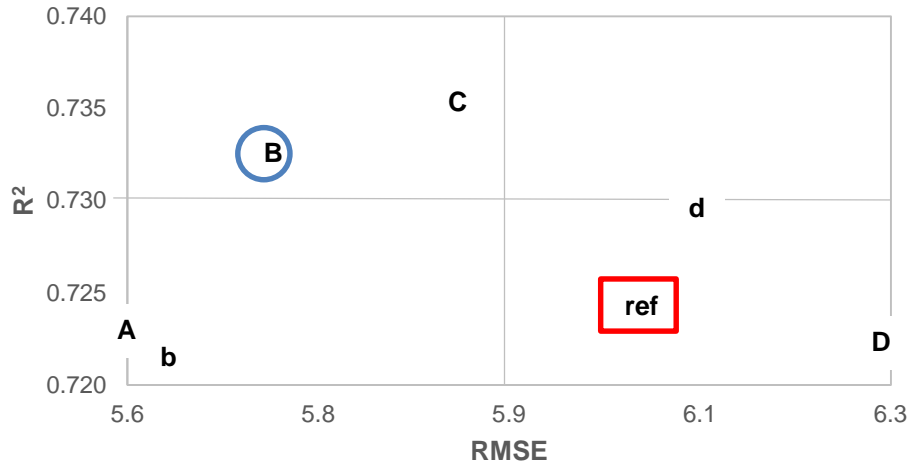


# Model evaluation / 2

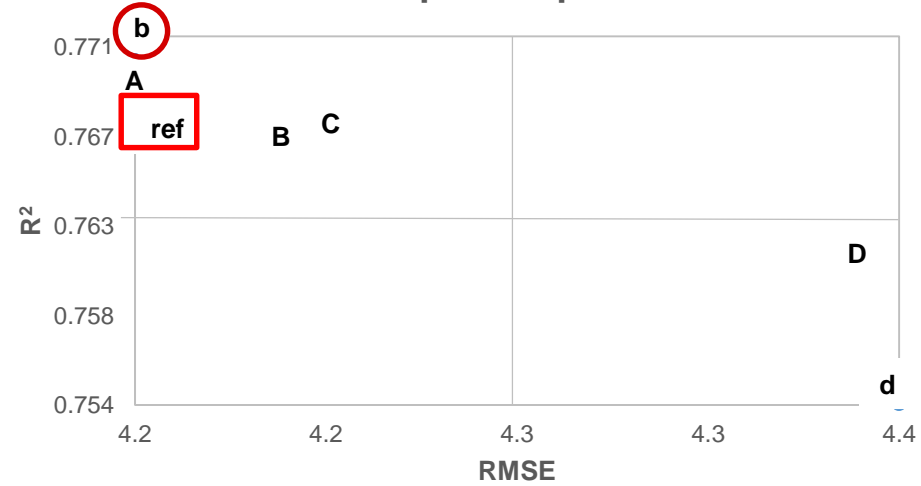
Intensive – Type B

Extensive – Type b

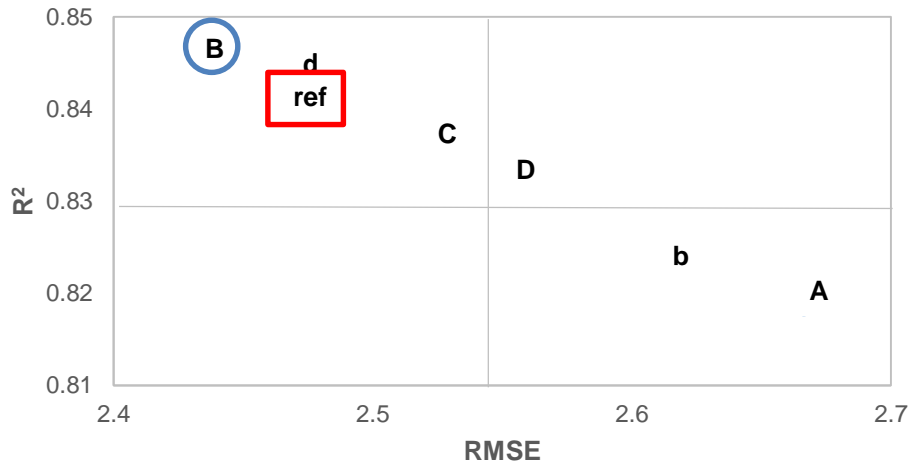
Actual evapotranspiration



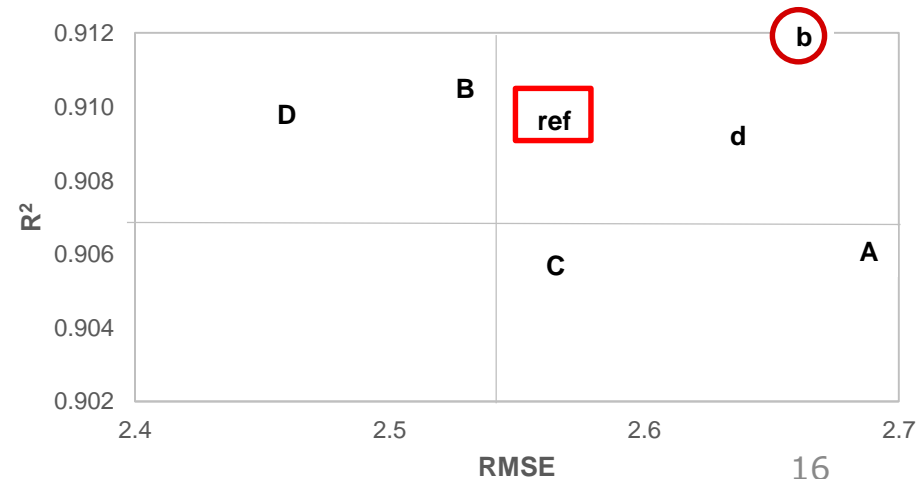
Actual evapotranspiration



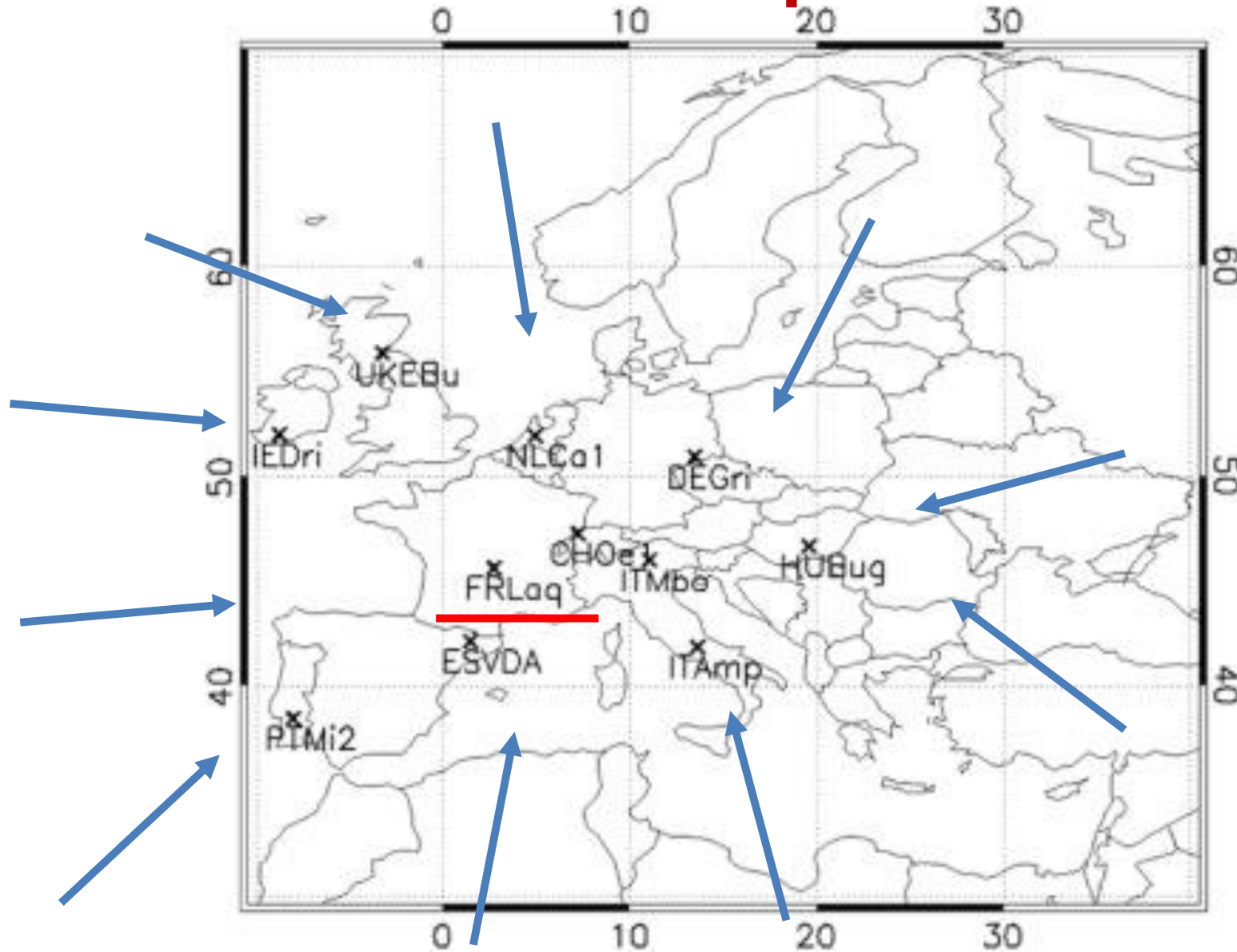
Soil temperature



Soil temperature



# Extension to other grassland sites in Europe







**Are PFT-based simulations sufficiently accurate?**

will always learn more about Animation  
/stack-of-books-vint

**Do we have something to gain or lose (beyond accuracy) through PFT-based modelling of grassland systems?**



The results of this research were obtained within an international research project named “FACCE MACSUR – Modelling European Agriculture with Climate Change for Food Security, a FACCE JPI knowledge hub”

