Modelling the impacts and feedbacks of climate change on the performance of grazing suckler cattle

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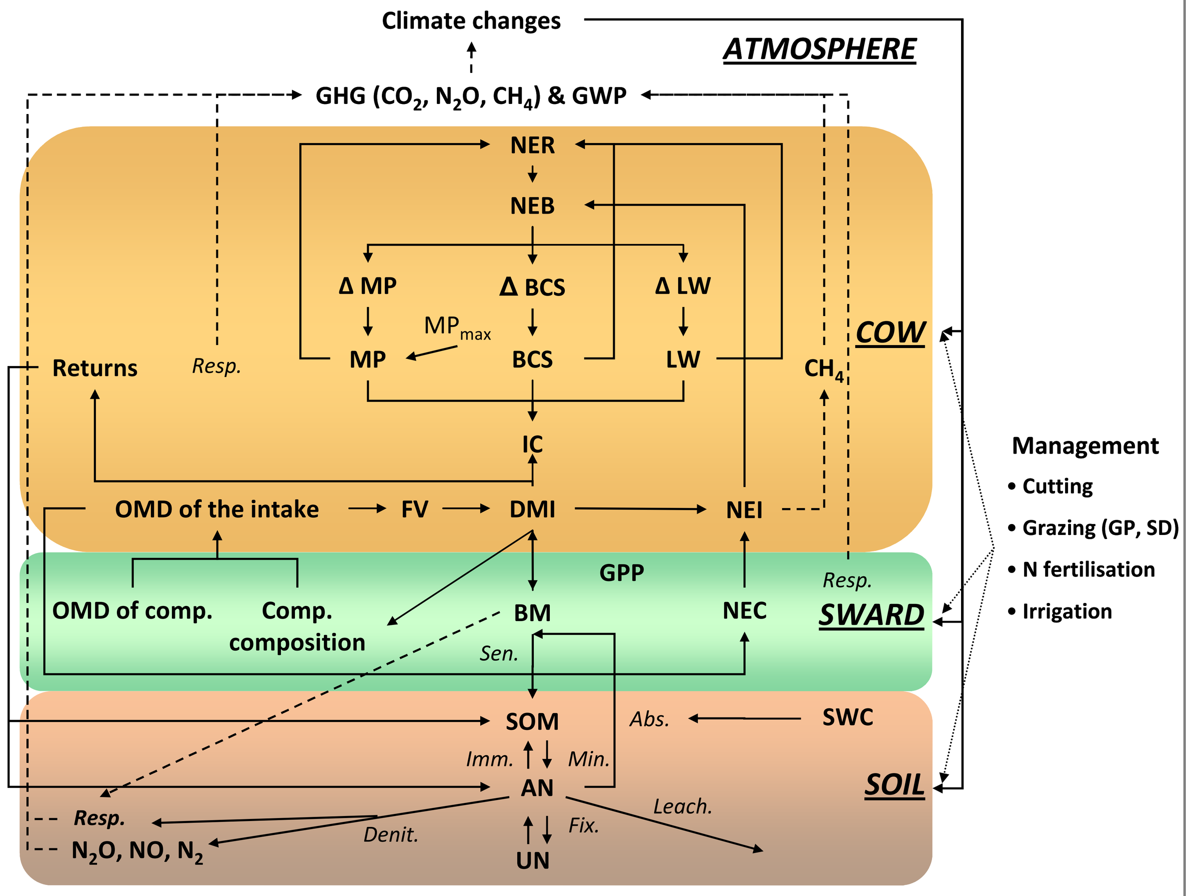
Introduction

Climate change may impact livestock both directly and indirectly through changes in the productivity, seasonality and quality of pasture production. In return, such changes may affect climate change, as pastoral farming contributes nowadays significantly to agricultural emissions of GHG. Only few livestock models are able to simulate accurately both biogeochemical fluxes exchanged in grassland ecosystems and animal performance. In order to simulate changes and possible feedbacks in the latter in a global warming context, we have coupled a biogeochemical grassland model simulating grazing, PASIM[1], and an animal production model[2].

Model improvement

PASIM simulates C, N, H_2O and energy fluxes in managed grasslands at the plot scale (**Fig. 1**). Ruminants are simulated at pasture, but not in the barn. They are moved out when BM is too low. The PASIM animal module considered a constant LW (milk production only) and diet was limited to grazed herbage. We have improved this module so that it can now simulate cow - calf performance, limitation of DMI by high temperatures [3] and CH_4 emissions [4] for both dairy and suckler cattle.



Nomenclature

Abs.	Absorption	LV	Live weight
AN	Available nutrients	Δ LV	Daily live weigth variation
BM	Biomass	Min.	Mineralisation
BCS	Body condition score	MP	Milk production
ΔBCS	Daily body condition score variation	Δ MP	Daily milk variation in production
CH4	Enteric methane production	MP_{max}	Milk maximum production
Comp.	Shoot compartments: lams, ears and stems	NEB	Net energy balance
		NEC	Net Energy content of grazed herbage
Denit.	Denitrification		
DMI	Daily herbage ingestion	NER	Net energy requirement
Fix.	Fixation	OMD	Organic matter digestibility
FV	Fill value of the herbage	Resp.	Respiration
GHG	Greenhouse gases	SD	Stocking density
GP	Grazing period	Sen.	Senescence
GPP	Gross primary production	SOC	Soil organic carbone
GWP	Global warming potential	SOM	Soil organic matter
IC	Daily ingestion capacity	SWC	Soil water content
Imm.	Immobilisation	UN	unavailable nutrients
Lea.	Leaching		

__Figure 1:__ Diagram illustrating how far the integration of animal performance in the PASIM model plays a role in climate change impact projections.

Validation against experimental data

We simulated a grassland-based suckler system at the Laqueuille site (upland grassland in the French Massif-Central). In this experiment a group of 6 young (3-4 years old) and 3 mature (≥5 years old) suckler cows with their calves (calving in early January) were grazing continuously at low SD (0,7 LSU.ha-1) for 5 months in 2005 on permanent pastures.

Model predictions of animal performance (**Fig.2**) are globally quite good and well reproduce the dynamics of observations. But BM is overestimated, perhaps because the model doesn't integrate the spatial heterogeneity of vegetation due to grazing. Moreover, model predictions of animal performance are very sensitive to the OMD.

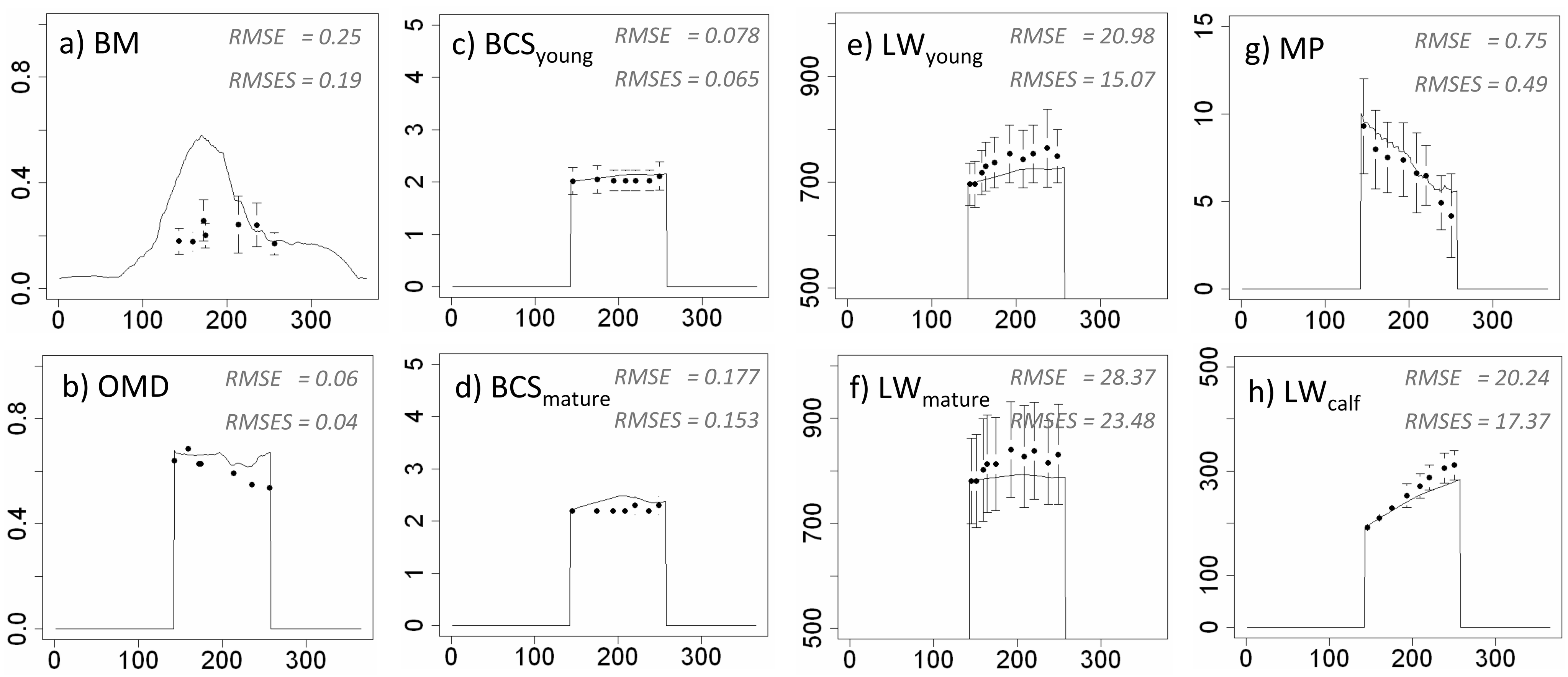


__Figure 2:__ Comparison of simulations (lines) vs. observations (dots) during the grazing period of a) BM (kg.m-2), b) OMD (%), BCS of c) young and d) mature cows (-), LW of e) young and f) mature cows (kg/animal), g) MP (kg/animal) and h) calf LW (kg/animal). Error bars show the variability in measurements. RMSE et RMSES are respectively global and specific root mean square errors.

Impact projections on animal performance and feedbacks

We simulated impact projection on animal performance for the previous livestock system and the A2 IPCC SRES scenario of the ARPEGE model at the Clermont-Ferrand station (400m a.s.l., 40km from Laqueuille). SOM was initialized at equilibrium with the climate in the 1950's.

When averaged over 30 years and compared to the reference period (1970-2000), with fixed agricultural practices (**Fig.3**) :

• Previous and new model responses to climate changes are different, (especially for SOC sequestration, N_2O emissions and GWP), demonstrating the importance accounting for animal performances in climate projections.

• GP lenght and daily LW gain could be reduced in far future, probably due to the decrease in summer GPP. CH_4 emissions remain at the same level.

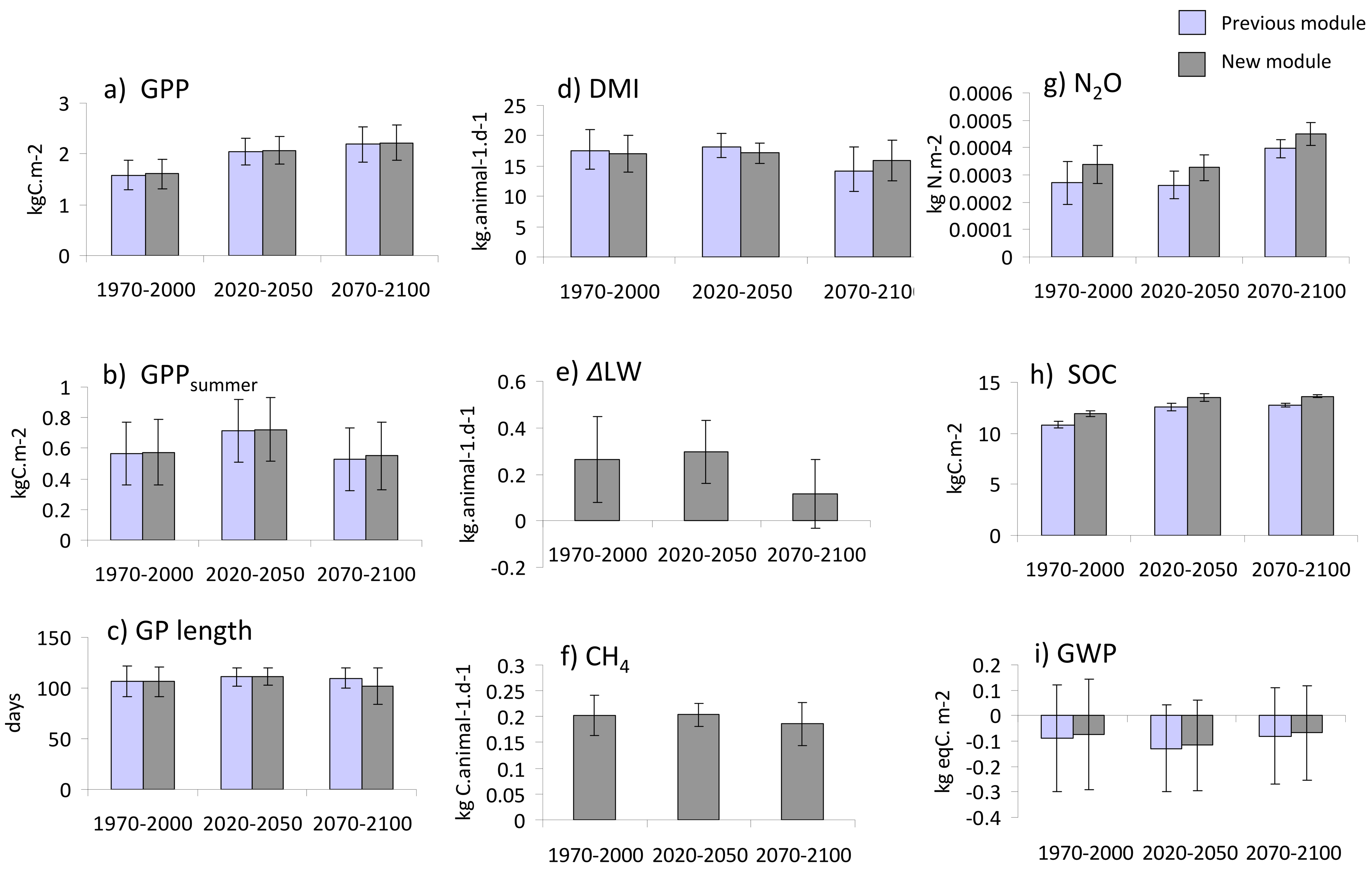


__Figure 3__: Projected climate change impacts over the grazing period of a) GPP, b) GPP in summer, c) Length of the GP, d) DMI, e) ΔLW, f) CH_4 g), N_2O, h) SOC, i) GWP for the A2 IPCC SRES scenario. Error bars show the interannual variability during the period.

Conclusions

These first results should be taken with caution, in regard to current model limitations for simulations of high temperatures and of severe droughts. Model tests and parametrisation against data from climate change experiments are planned and should allow more realistic projections of climate change impacts. Moreover, as model is highly sensible to OMD, vegetation traits are needed to derive this parameter under climate changes. Simulations with adaptations of agricultural practices (N fertilisation, Cutting and Grazing) are also planned and will complete these results.

[1] Riedo et al. 1998, Vuichard et al. 2007, [2] Jouven et al. 2008, [3] Freer et al. 1997, [4] Vermorel et al. 2008