Representing sahelian agro-ecosystems in the IPSL global land surface model ORCHIDEE: in situ validation and comparison between croplands and grasslands

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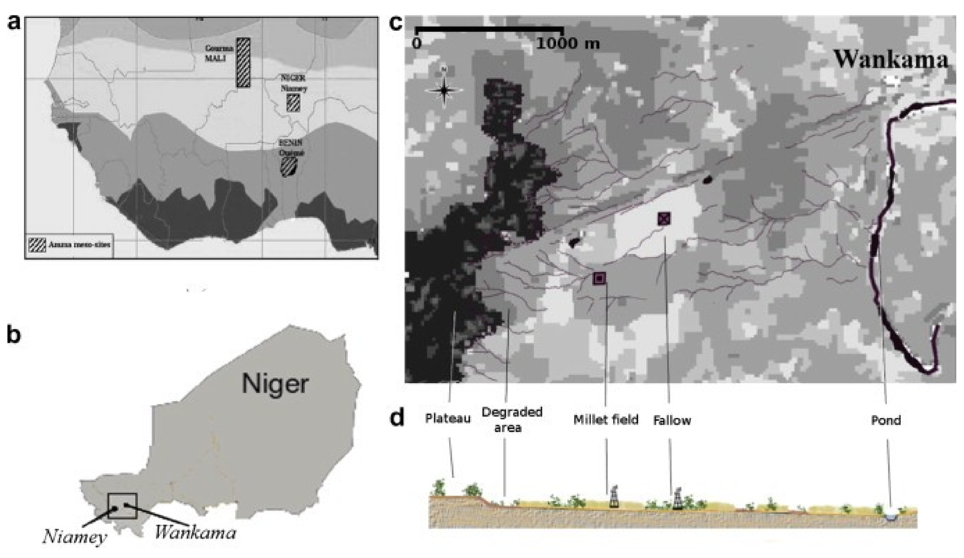
Context and objectives

West Africa is a region where land/atmosphere interactions play a strong role on climate. These interactions are mainly driven by local vegetation characteristics and dynamics. In order to improve the representation of this vegetation and the simulation of its interactions with the atmosphere in the IPSL terrestrial biosphere model ORCHIDEE, recent model developments have been carried out to better account for African agro-ecosystems: specific representations of natural grasslands (savannah) and croplands (sorghum/millet) have been implemented, in place of the single generic grassland parameterization used in the original version of the model for both plant types (with slightly different parameters).

Here, we compare the simulations performed with this new version of ORCHIDEE against in situ data from the AMMA-Niger Wankama “local site”, in order to assess the ability of the two land-cover specific parameterizations of the model to capture the respective observed characteristics of vegetation, water balance and energy fluxes over diurnal to inter-annual time scales. We also discuss the ability of the model to account for the relative differences between crops and fallow in terms of land/atmosphere interactions.

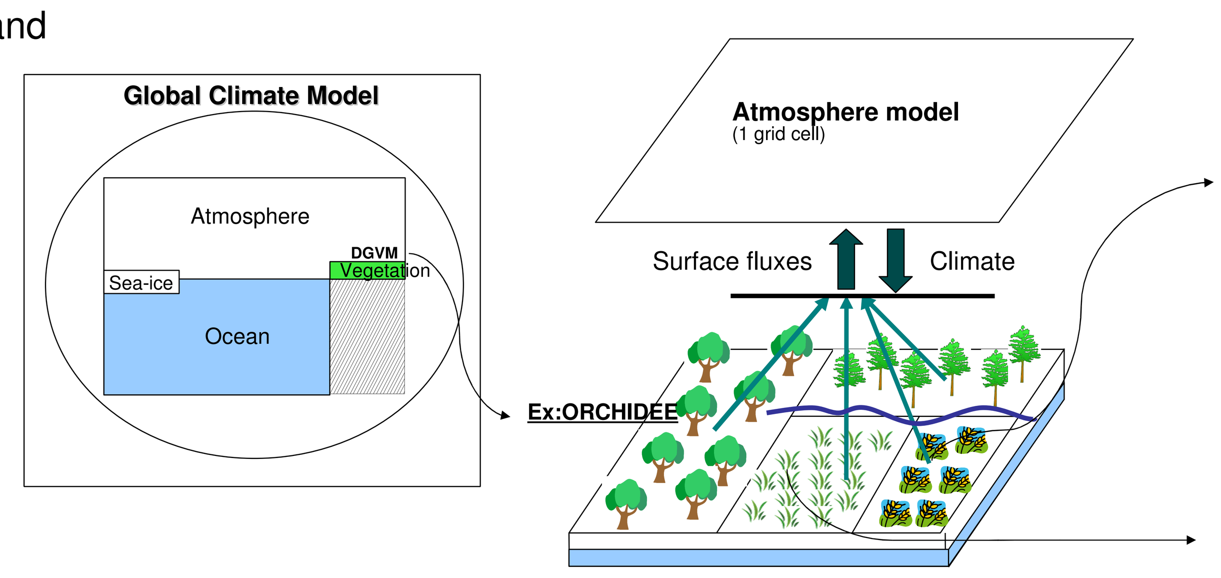
The Wankama site in Niger

Since 2005, measurements of weather, biomass, energy and carbon fluxes have been carried out over two neighboring sites with distinct land cover types, fallow and millet.



The Wankama catchment in the AMMA-Niger meso-site. Location of meso-site (square) in: (a) West Africa; (b) the Niger Republic; (c) Map of Wankama catchment with location of EC systems (squares); and (d) Toposequence of Wankama catchment. From Ramier et al, 2008 (1)

ORCHIDEE-millet and ORCHIDEE-savannah



ORCHIDEE-millet (2):

Process and parameterizations taken from the CIRAD crop model SARRAH:

- sowing based on rainfall
- cycle length based on GDD requirements (~90days)
- cycle is divided into vegetative and reproductive phases, with specific allocation rules; ends by a harvest
- assimilation and hydrology not modified.

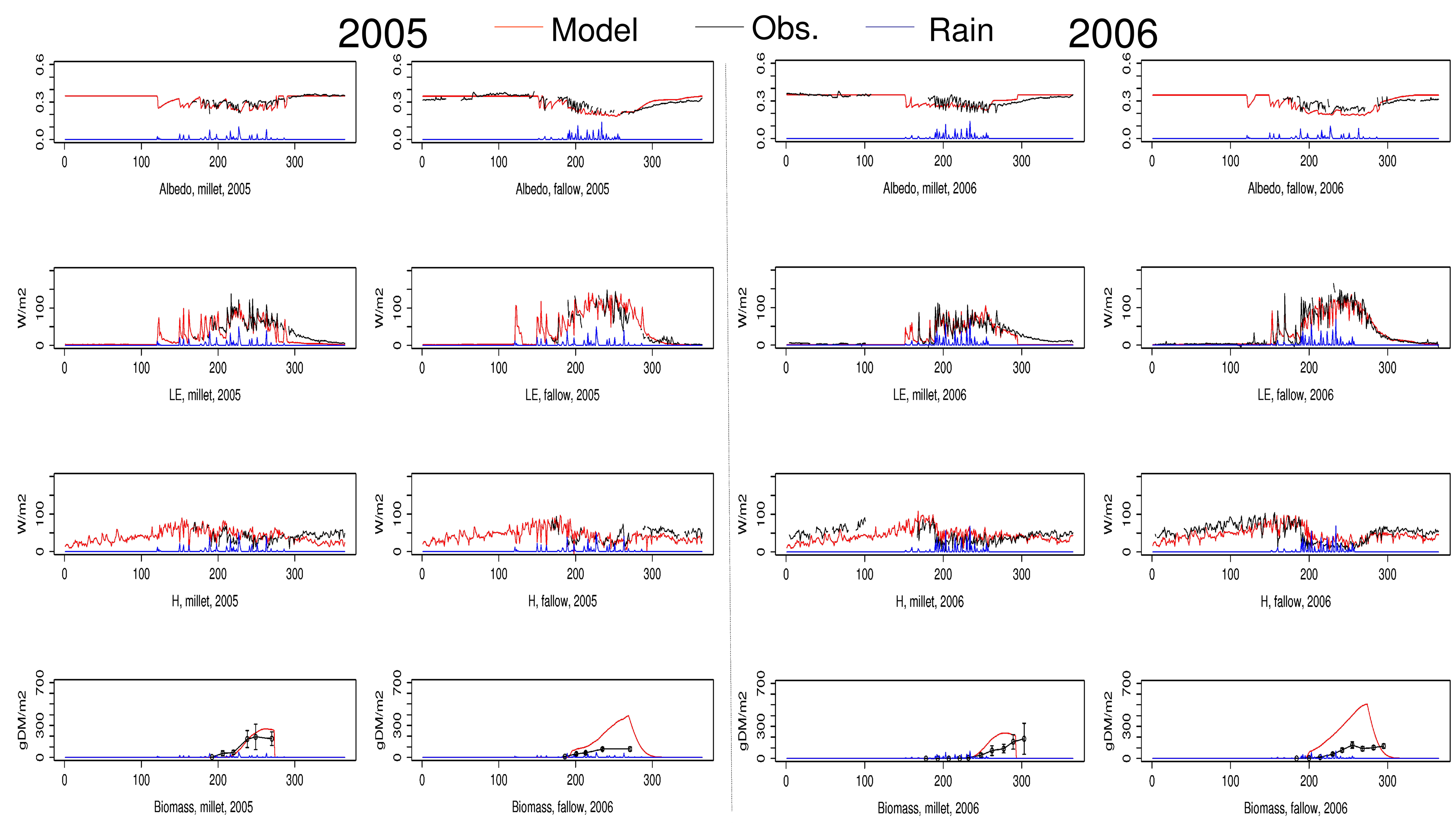
ORCHIDEE-savannah (3):

Original grassland parameterizations from ORCHIDEE adapted, after calibration on the Agoufou site (Mali):

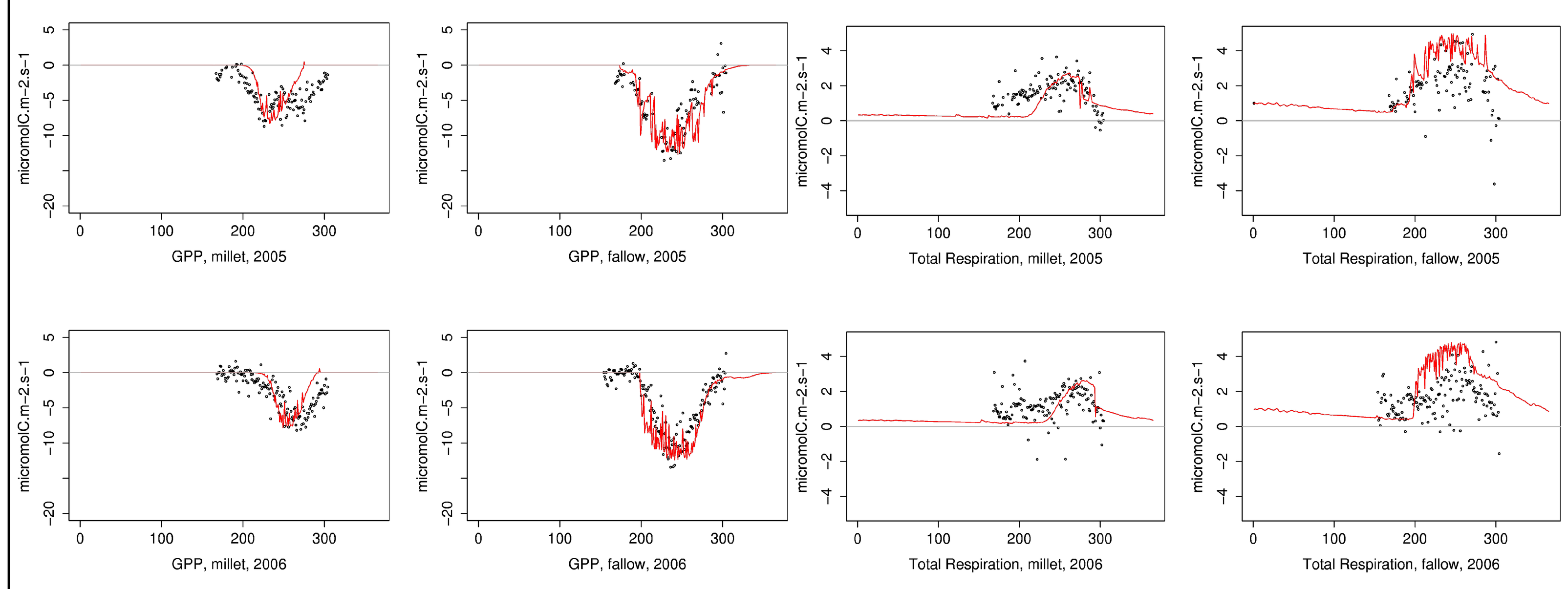
- Modified phenology (cycle start based on soil water content; more abrupt senescence)
- higher photosynthetic capacity.

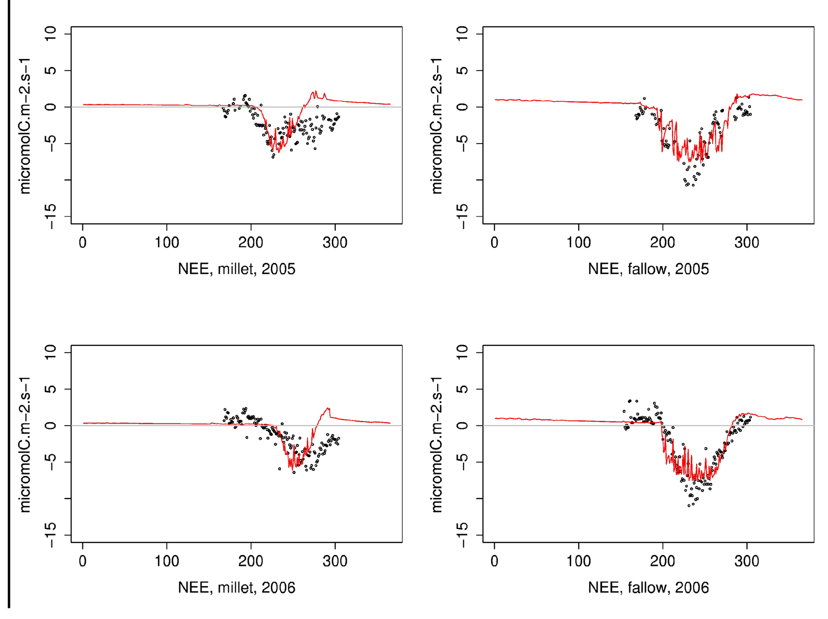
ORCHIDEE is forced with 2005/2006 observed weather and incoming radiation (SW, LW). Wet and dry soil albedo values are prescribed, as well as vegetation fractions.

Seasonal cycle of energy fluxes and biomass



Seasonal cycle of carbon fluxes





Gross Primary Production (**GPP**) is correctly simulated by the model (in green)

Total (autotrophic + heterotrophic) **Respiration** is slightly overestimated, particularly for the fallow

As a result, Net Ecosystem Exchange (**NEE**) is slightly too small in the model.

On both sites, vegetation development in the model occurs with the right timing. However, **biomass** on the fallow site is largely overestimated; biomass on the millet site is in better agreement with observations, but in 2006 the model partly misses the late development of millet.

Latent heat flux (LE) is accurately simulated by ORCHIDEE, in terms of seasonal dynamics and absolute values. However, after harvest simulated LE falls to zero on the millet site, whereas evapotranspiration still remains in the observations: this is probably due to the absence of raingreen-leaf bushes in the model, that may still transpire at the end of the rainy season.

The dynamics of **sensible heat flux** (H) is well reproduced compared to the observations; however, the model is strongly biased, positively during the rainy season, negatively during the dry season. Soil temperatures and outgoing long-wave radiation also show biases (not shown). Further investigation is needed to understand the causes of these errors.

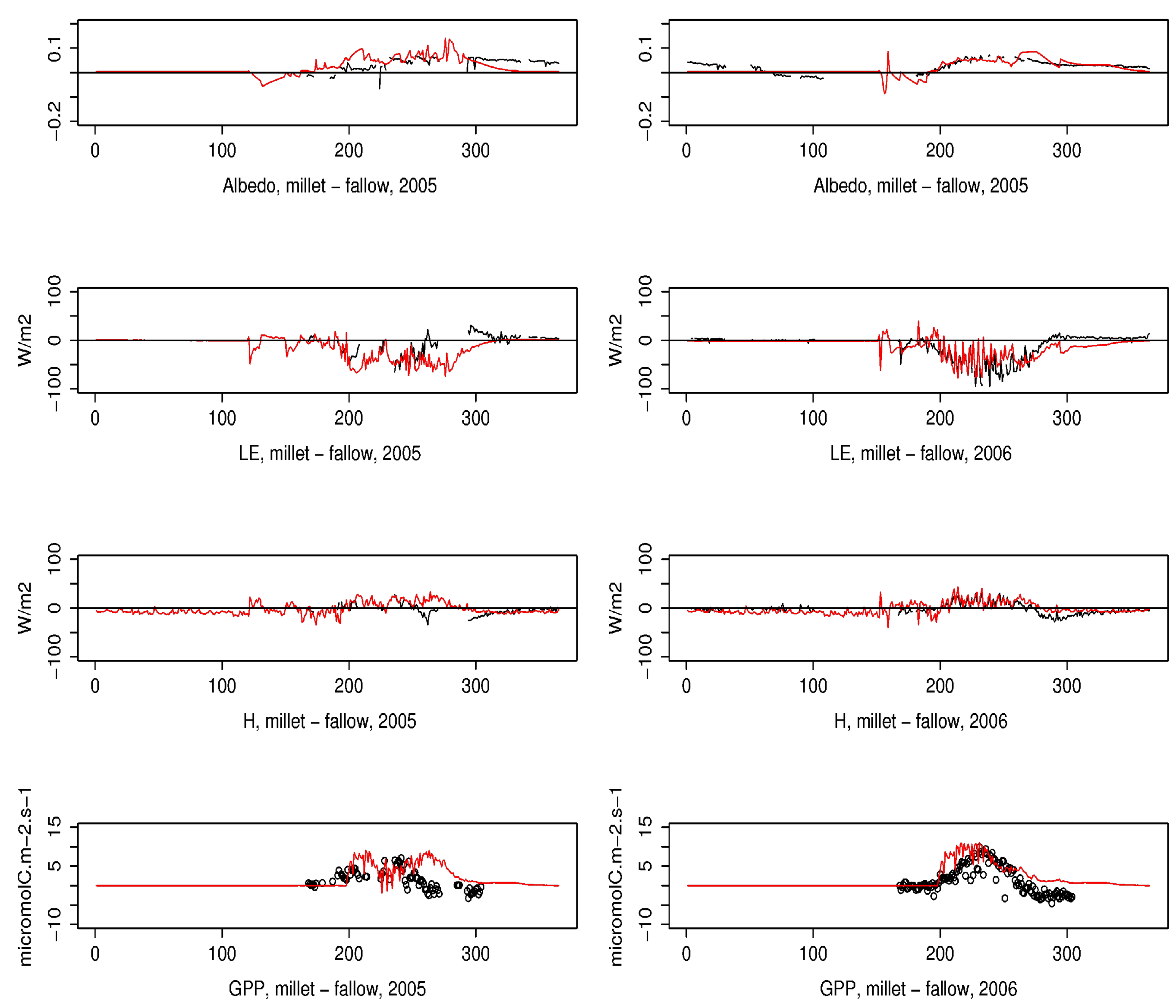
Despite **these discrepancies** over each sites, the model correctly captures the **main differences in land/ atmosphere interactions due to land-cover type** (particularly in 2006) :

- higher albedo over millet than fallow
- higher LE, and lower H, during the rainy season over the fallow, however, because ORCHIDEE-millet underestimates LE at the end of rainy season (see above), the observed differences in LE and H are not captured by the model.
- higher GPP on the fallow site (and since total respiration is similar on the two sites, higher NEE)

It is also interesting to note, despite the limited number of years, that the model reproduces some features of interannual variability:

- the stronger development of the fallow in 2006 compared to 2005, and the opposite for millet
- the delayed vegetation peak on the millet site in 2006 compared to 2005, as rain season in 2006 set in later; whereas the fallow vegetation peaks at the same time each year.

Differences in land/atmosphere fluxes due to land-cover types.



CONCLUSION

Simulations by our new version of ORCHIDEE including specific representation of African croplands and grasslands are overall in good agreement with in situ measurements over the Wankama sites. Most of the discrepancies result from standard model biases rather than from our specific parameterizations.

The model seems able to capture the main differences in land/atmosphere fluxes between the two land cover types, as well as the differences in interannual variability between the two sites. This gives confidence in the use of the model to study the impacts on land/atmosphere interactions of land-cover changes over the Sahel in recent decades (increase of croplands at the expense of natural grasslands.

References:

1)Ramier et al (2008): Towards an understanding of coupled physical and biological processes in the cultivated Sahel – 1. Energy and water, *Journal of Hydrology.*

2) Berg et al : Including tropical croplands in a terrestrial biosphere model: application to west Africa. *Submitted to Climatic Change*

3) Brender et al : Evaluation and improvement of the representation of sahelian savannah in the vegetation model ORCHIDEE *poster EGU, EGU2009-11895.*