Interactive comment on "Surface response to rain events throughout the West African monsoon" by F. Lohou et al.

Response to Anonymous Referee #2

We thank both reviewers for their comments on our manuscript. Here is a detailed response to referee # 2.Two figures have been changed to show more data/model comparisons.

• 18582-2: "a rain event" -> "rain events"
This will be corrected in the new manuscript version. Thank you.

• .82-17: add "than observed"
This will be corrected in the new manuscript version.

• .83-14: worth referring to Guichard, F., L. Kergoat, E. Mougin, F. Timouk, F. Baup, P.Hiernaux and F. Lavenu (2009): Surface thermodynamics and radiative budget in the Sahelian Gourma: Seosonal and diurnal cyclus; J. Hydrol. 375, 161-177, doi:10.1016/j.hydrol.2008.09.007
This reference will be included in the new manuscript version.

• .83-21: give a reference to this failure to simulate this in GSWP2
"Based on a comparison with data, Teuling et al 2006 stated that GSWP-2 models could still be improved."

• .86-3: is "Sudanian" refering to a West African climate regime? I'm confusing it with the country Sudan
Sudanian climate does not refer necessarily to the Sudan country. Sudanian savanna runs from east to west across the African country and lies just south of the Sahel.

• Fig 2: "shifted above 1" not entirely clear
The legend of Figure 2 will be changed and we suggest: « Weekly (black) evaporative fraction EF and its standard deviation **(σEF +1 is plotted in order to avoid superposed curves).**.. »

• .88-25: "to distinguish bare soil from vegetation cover": not sure I understand what you mean. Do you reconstruct a fractional area bare ground from the ET/TR results?
We simply used the TR/ET fraction to distinguish between sites dominated by bare soil verses vegetation cover. The sentence has been changed and it reads:
« The simulated transpiration (TR) allows an estimation of the vegetation activity. A threshold of 0.1 for transpiration to evapotranspiration ratio (TR / ET) will be used to distinguish <u>sites dominated by bare soil verses soil with vegetation cover</u> »

Why doesn't fig 3 show the eddy correlation observations of EF?
A direct comparison of simulated and observed EF can only be performed for the year 2007 for which the two data sets overlap. We then suggest to add a new figure (figure 4 below). However, it is worth to precising that only the general trend (maximum value reached during the monsoon season, and decrease of EF after the last rain event) can be compared since the local rainfall measured at the site differ in both distribution and amount from the rainfall prescribed to the LSM grid.

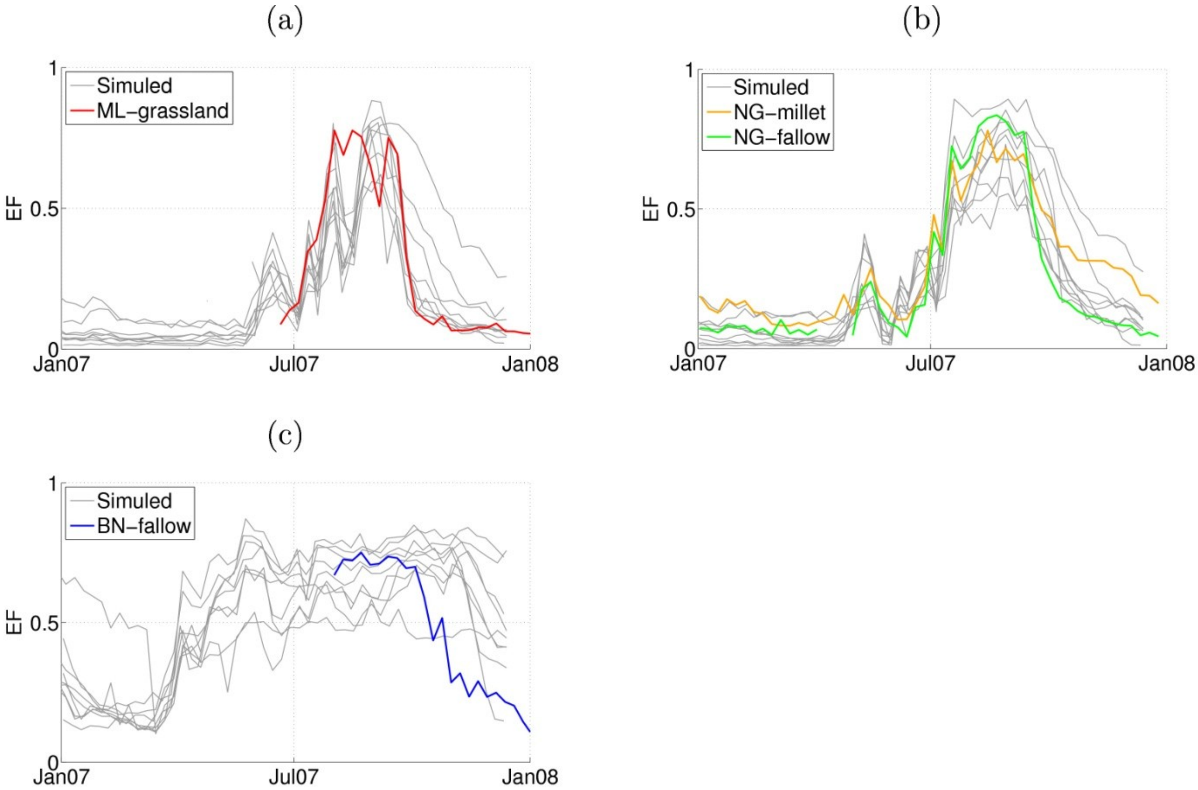


Figure 4: Weekly evaporative fraction (EF) from january 2007 to December 2007 simulated at (a) Hombori , (b) Niamey and (c) Djougou (grey lines) and observed at (a) ML-grassland , (b) NG-millet and NG-fallow, and (c) BN-fallow (colored lines).

• .89-27: for the models closure of the water balance can be ensured by taking an appropriate soil depth definition. For the observations the limited dynamical range in S can be related by missing dynamical features from deeper layers, not contained in the observations. Can that be a reason for the discrepancy?

The paragraph has been modified in order to discuss the effect of the soil moisture seasonal variation of deeper layers (between 1 and 1.5 m).

« The same features can be observed at Niger and Mali sites where a 50 to 70 mm variation of soil moisture is measured and a 100 to 150 mm variation is simulated. Such a difference is likely due to the deeper soil layer simulated by the LSM than the 1m-depth layer considered in the experiment to estimate the vertically integrated soil moisture. The soil moisture seasonal variation of the layer between 1 and 1.5 m-depth varies from 20 to 40 mm according to the site and the year in Niger and Mali (not shown); unfortunately, the soil moisture measurements below 1 m are not available at all sites and with a sufficient temporal coverage .»

• .92-10: the symbol tau2 was not introduced yet, it’s a bit unclear in this context

Equation (4) will be introduced before the discussion on tau 2 in the new version of the manuscript.

• .93-24: Bare soil evaporation is said to be the dominant feature here. But I as- sume that also the transpiration activity slows down after a rainfall event. You do analyse this in Fig 7. It’s worth referring forward to this figure at this point.

Fig. 5 shows the immediate response of the surface after a rain event against the soil moisture. In line 93-24 we discuss the fact that the immediate response is high when the soil moisture is very

low. These conditions occur at the beginning of the monsoon season when the LAI is almost zero at Niger and Mali sites. So there is no transpiration during these very high immediate responses.
Fig. 7 shows a slow down of the transpiration but during the recovery period, from D2 to D5.

• .94-4: "seasonal cycle of surface recovery" is a bit imprecise. Do you mean the seasonal cycle of the recovery time scale?
We agree this sentence is unclear. It reads now: « As expected, the seasonal cycle of the surface recovery amplitude is close to the cycle of the immediate response amplitude. »

• Fig 6: does this strong relationship imply that one can describe the surface re- covery well with just a single time scale?
We agree that there is a strong relationship mainly due to the similar seasonal evolution of both immediate and recovering surface response amplitudes (EF(D1)/EF(D0) and EF(D1)/EF(D2)). However, this is a log-log diagram which consequently hides the dispersion. The dispersion about the dashed line is not necessarily associated to measurements errors but can represent the various situations. Low power law (points under the dashed line) can represent situations for which the intercepted water evaporation amplifies the immediate response. Power law above 1, which is often the case during the core of the monsoon, could be associated with rain events over saturated soil (low immediate response) and high evapotranspiration the day after due to strong solar irradiance. Then a single time scale would allow describing a seasonal evolution but surely not the variability among the cases.

This will be discussed in the next version of the manuscript.

• .94-14 and legend Fig 7: "Rain are sorted in 2 categories": a bit strange to sort "rain" into two surface type categories. What do you mean?
We agree that the sentence was misleading; we suggest the following change in the text:
« The rain events are further sorted in two categories: rain events occurring above bare soil for LAI < 0.01, and rain events occurring above surface with vegetation coverage with LAI > 0.01. »

We suggest the following changes in Figure 7 legend: « Evolution of the daily normalized evaporative fraction (EF / EF(D1)) before and after rain event for (a) ML-grassland, (b) NG-fallow, (c) NG-millet, (d) BN-forest (e) BN-fallow. Thin and bold grey lines stand for individual rain events and their median, respectively. Thin and bold dark lines stand for exponential fit with $\tau 1$ and $\tau 2$, respectively. Rain are sorted in two categories: (continu- ous line) **rain events occurring above bare soil (LAI ≤ 0.01), and (dashed line) rain events occurring above soil with vegetation cover (LAI>0.01)**. »

Actually, you don't discriminate along vegetation per se, but distinguish early from late monsoon conditions, wheremuch more than only vegetation can be different (soil moisture, rain patterns, potential evaporation)

Several parameters actually impact the surface recovery, and this is discussed in the response to reviewer comment on Fig6.
We agree that soil moisture and vegetation coverage have a similar seasonal cycle and discriminate along one of these two parameters can seem therefore difficult. However looking at figure 2, one can remark that rain events over bare soil (LAI ~ 0) and over surface with vegetation coverage (LAI > 0) occur for a wide range of soil moisture in both case. Discriminating along the soil moisture would lead to different results; rain events over bare soil at the beginning of the season would be mixed with rain events over soil with vegetation coverage at the end of the season. Moreover, the simple distinction between vegetation or bare soil is convenient to make two major points: i) plant

types end especially the perennial versus annual types is a strong determinant of EF dynamics. ii) Models differ even in bare soil evaporation dynamics.

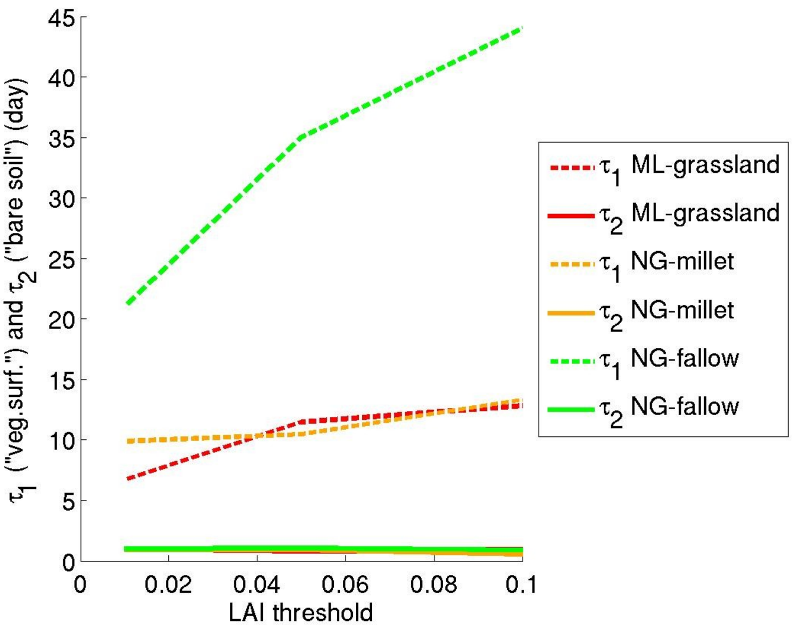
• .94-16: LAI = 0.01 seems to be a very low value to discriminate vegetation from bare ground. Is your result sensitive to this choice?

We agree that the sensibility of the recovering time scale (tau1 and tau2) to the LAI threshold is interesting to discuss. The choice of this treshold determines how many rain events will be considered occuring over « bare soil » and how many are considered occuring over « vegetated surface ». Sorting out rain events in just two categories whereas the vegetation growth is a progressive process throughout the season, over-simplifies the description. But we do not have enough rain events to consider more than two categories, and the framework proved usefull two make two strong points (a said above).

We choose a low threshold in order to discriminate totally bare soil from surfaces slightly to highly vegetated. The choice of a higher LAI threshold would imply to consider a different value for each surface site, the LAI evolution being very different among the site and vegetation cover. A LAI threshold of 0.1 for example represents half of the maximum value at NG-millet and just 10% or 5% of the maximum value at NG-fallow (depending on the year). We performed a sensitivity study on this LAI threshold.

An increase of the LAI threshold moves some rain events, for which the vegetation is rare, from « vegetated surface » to « bare soil » category. Logically the recovery time scale of « vegetated surface » should increase and the time scale for «bare soil » keeps constant with increasing threshold. This is shown in the following figure. This reinforces our statements that annual vegetation has similar behaviours (ML-grassland NG-millet), and that the fallows have similar behaviours also (NG-fallow, BN-fallow) despite being in different climates.

We will discuss the reasons why we chose a low LAI threshold for this study in the next version of the paper.



• Fig 8: why not plot the observations in as well (in color)?

We have prepared a new version of figure 8 which includes observations.

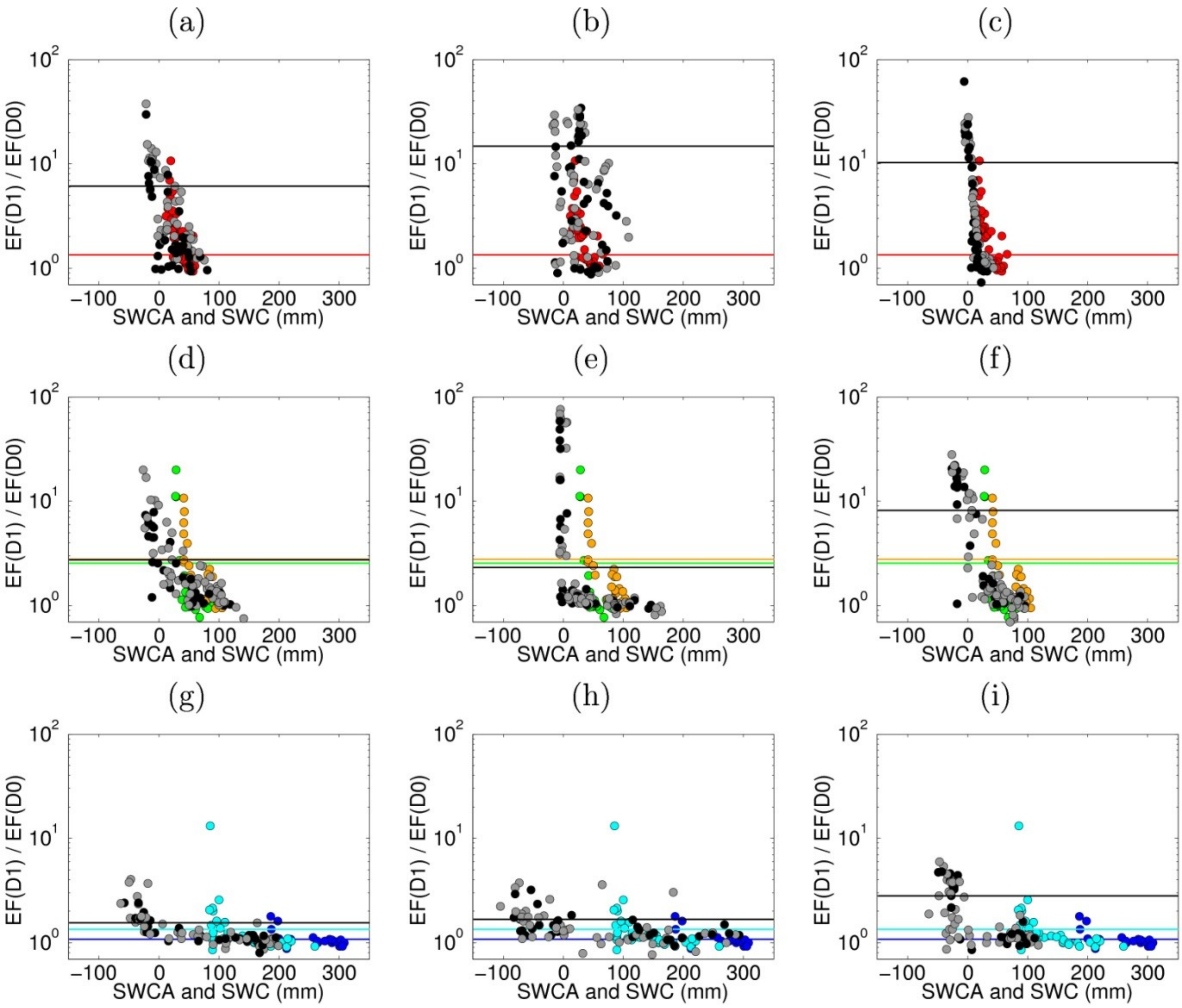


Figure8: Exemple of simulated surface immediate response (EF(D1) / EF(D0)) against soil water content anomaly (SWCA) just before the rain, for (a to c) Hombori, (d to f) Niamey, and, (g to i) Djougou locations with 3 of the 9 LSMs involved in ALMIP (left, middle and right panels are for NOAH, HTESSEL and SsiB, respectively). Grey and dark circles are for cumulated rainfall < 8 mm and > 8 mm, respectively. Colored circles are for observed surface immediate response against soil water content (SWC) at (a to c) Mali site, (d to f) Niger sites and (g to i) Benin sites. Horizontal colored and black lines stand for EF(D1) / EF(D0) upper quartile in the experiment and simulation, respectively.

• Fig 10: any reason why HTESSEL is such an outlier in TR/ET? I know ECMWF has been working on their bare ground evaporation module. Is this included in the simulations shown here?

For ALMIP 1, HTESSEL was not running the version recently published. Since this intercomparison experiment, some modifications have been made which tend to increase bare soil evaporation and would perhaps reduce HTESSEL outlier behavior (but this has not been verified). There is not much we can say at this point.

• .99-3: “threeshold” -> “threshold”

This will be corrected in the new manuscript version.

• .99-7: you say the phenology is of interest, but as said above, other aspects of the hydrological budget also change drastically parallel to the phenology. How do you know the phenology is such a strong determinant?

In fact, we have rewritten this section, and replaced phenology by plant type, insisting on the difference between annual plants and perennial plants. Indeed, existence of a perennial root system (fallows in Niger, Benin, forest in Benin) is a strong determinant of EF dynamics, which lead to similar EF e-folding times for the two fallows and the annual dominated sites (millet crop and grassland). Conversely, in the same climate, there are strong differences between millet crop and fallow (Niger). We hope the text will be much more clear in the next version.