

Interactive comment on “A leaf area index, LAI, data set acquired in Sahelian rangelands (Gourma, Mali) over the 2005–2017 period” by Eric Mougin et al.

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Reviewer #2:

First, I would like to appreciate the efforts that have been taken by the authors to collect and analyze 13-years field measurements for the manuscript “A leaf area index, LAI, data set acquired in Sahelian rangelands (Gourma, Mali) over the 2005-2017 period”. Secondly, the open-access dataset provided by the authors will be an asset for future research use, which is quite appreciable indeed.

Thank you for your positive appreciation.

C1

However, I believe the manuscript requires major revisions mostly about the way it is written and the structure and text body of especially abstract, introduction, site description, and field sampling strategy and data description. It gets sometimes very difficult to follow the logic and methodology used in this manuscript. I also recommend the authors to fix the sentence structure, e.g., avoid run-on sentences, and grammatical and spelling issues that I have noticed throughout the paper.

Thank you for your valuable comments and suggestions of. We improved the manuscript according to your recommendations.

In addition, I would recommend the authors to rerun the data analysis using yearly MODIS imagery corresponding the year of collected data in the field, which I will explain it later in my list of comments.

Thank you for your advice. In fact, we detected a problem with the data we extracted from the MODIS site, due to a numerical conversion error we made. This problem has been fixed and the corresponding figures (Fig. 5a and 5b) have been modified (see below).

Furthermore, the current type of provided line numbers makes addressing comments very difficult.

Sorry for that but we followed the current type of line numbers provided by the journal.

Here are some of my concerns and comments regarding this manuscript :

1. The title doesn't carry out the main picture and purpose of this research. Also, as I found the study region is in the northern Sahel and thus the title needs to be changed as “. . .rangelands in the northern Sahel. . .”

This paper aims to present briefly the long term measurements of LAI performed in the Gourma region in Mali, and the associated open data base that was built for disseminating the data to the research community. Our motivation was also to show a few examples of data use.

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Field measurements were performed in Northern Mali, between Mopti and Gao, and for many authors, this region belongs to the Sahel zone proper (e.g. Le Houérou, 1989) from a biogeographical point of view. Accordingly, we suggest to keep the term 'Sahel' but, as suggested, we modified the title as:

ÀÁA leaf area index data set acquired in Sahelian rangelands of Gourma in Mali over the 2005-2017 periodÀž.

Le Houérou H.N., 1989. The grazing land ecosystems of the African Sahel. *Ecological Studies* 75, Springer-Verlag, Berlin, 295p.

2. Abstract, P 2, L5-10, you can't draw a strong conclusion about using this dataset for a better understanding of the Sahelian vegetation response to the current rainfall changes unless you scientifically provide evidence that this study area at the northern Sahel has similar vegetation community with the rest of the Sahel.

Yes, you agree. We are aware that the Sahel region is not as homogeneous as it is often described. However, due to its climate, soil types and vegetation characteristics similar to many other Sahelian regions, the Gourma site was selected as one of the two Sahelian study sites within the frame of the international African Monsoon Multidisciplinary Analysis project (Lebel et al., 2010). It was also selected in 2010 by the international 'Tropical Biomes in Transition' project, TROBIT, (www.geog.leeds.ac.uk/TROBIT), to be representative of the Sahelian zone of West-Africa. Field studies supported by NASA have also been conducted in the 1980s, to support satellite observations of the whole Sahel (e.g. Hiernaux and Justice, 1986).

We added the following sentence in the Introduction section: "In 2010, the Gourma site was also selected as the Sahelian pilot site of West-Africa for the international 'Tropical Biomes in Transition' project (TROBIT) (www.geog.leeds.ac.uk/TROBIT). Àž

. Lebel et al., 2010. The AMMA field campaigns: Multiscale and multidisciplinary observations in the West African region. *QJRMAS AMMA Special Issue*, 136, 8-33, doi:

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doi.org/10.1002/qj.486. . Hiernaux P. and Justice C.O., 1986. Suivi du développement végétal NOAA au cours de l'été 1984 dans le Sahel malien. *Int. J. Remote Sensing*, 11, 1515,1531.

3. 1. Introduction, L5, please add the exact internet link for this reference (GCOS, 2011) in the citation list and look at the following reference and include it, Bojinski et al. 2014. The Concept of essential climate variables in support of climate research, applications, and policy. *Bull. Am. Meteorol. Soc.* 95:1431-1443.

Following your suggestion, we added the internet link for GCOS (2011) in the reference list. We also added the Bojinski et al. (2014) reference in the Introduction.

GCOS. Systematic Observation Requirements for Satellite-based Products for Climate, Supplemental Details to the Satellite-based Component of the Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC (update, December), 2011, available at https://library.wmo.int/doc_num.php?explnum_id=3710.

4. P 3 L10, "The seasonal variation of the ECVs, i.e. the vegetation phenology" please change it to "... , i.e. changes in the vegetation phenology".

As suggested, this has been changed (P4, L11).

5. P3 L20, "low trees" is vague. Does it mean short stature trees or dispersed trees?

To make it clearer, this has been changed (P4 L22) to: "scattered stands of shrubs and low trees".

6. P3 L35, MODIS needs to be in parentheses. Please add all abbreviations in the parenthesis and be consistent about using your terminology.

OK, corrected.

7. P3 L35, "...instruments have been providing continuous estimation of the ECV...". Please change it to "... have been used to provide a continuous estimation. ...".

C4

As suggested, this has been changed.

8. P3 L35-40, You mentioned past research emphasized on using spatially heterogeneous rangeland for validating ECVs on for example MODIS imagery, but at the beginning of next page, you are describing your study site as having lowest spatial heterogeneity. Looks these statements are contradictory. Please explain why your selected study site was different from what literature pointed out about the spatial heterogeneity

Field sites characterized by a high spatial heterogeneity are a big challenge for validation studies using moderate resolution (between 500 m to 1 km) instruments, due to the difficulties associated with field sampling at the scale of the satellite resolution, and also because of non-linear effects. The herbaceous vegetation canopies of the Gourma sites are heterogeneous at a fine spatial scale, between a few meters to tens and hundreds of meters, but are homogeneous at a broader scale larger than the satellite resolution which is a major advantage because of the satellite pointing errors.

The sentence was rephrased as: "Among the selected validation sites, the Gourma site stands out as the one with the lowest spatial heterogeneity at the resolution of moderate resolution sensors (Garrigues et al., 2006). This is a major advantage for validation studies because of the ground geolocation uncertainties of satellite products (Garrigues et al., 2008)."

9. P3 L40, the whole sentence from "With the main objectives. ...gov/) projects." is a vague run-on sentence. Please break it down to smaller clear sentences. Also, is it the objective of this study? If so, you need to clearly state this objective. I assume you have two main objectives: 1- validation of computed vegetation indices from the satellite imagery such as MODIS 2-providing open-access dataset. You need to deliver these main objectives at the end of introduction in a clear and strong way.

As suggested, we rephrased the sentence as (P4 L41):

"In 2000, the Sahelian Gourma sites have been integrated among the site network

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used in the Validation of Land European Remote Sensing Instruments (VALERI) project (Baret et al., 2005; www.avignon.ina.fr/valeri/; Camacho et al., 2013) and the Committee on Earth Observation Satellites (CEOS)/Land product validation (Morissette et al., 2006; <http://lpvs.gsfc.nasa.gov/>) projects. Among the selected validation sites, the Gourma site stands out as the one with the lowest spatial heterogeneity at the moderate spatial resolution scale. This is a major advantage for validation studies because of geolocation uncertainties of satellite products (Garrigues et al., 2008)."

10. P4 before L5, "Before the set-up of a seasonal ..." this sentence is about field sampling strategy and needs to go to that section.

OK, as suggested, this sentence has been moved to the field sampling section (Section 3).

11. 3. Site description, P4 L10, please change "the annual rainfall mean" to "the mean annual rainfall".

OK, corrected.

12. P4 L20, what is "super-site"? Please explain it at the first time you are using it.

The super-site is a 50 km x 50 km area in which all the validation sites are located. The Hombori super-site is shown in Figure 1 and described in Section 2.

13. P4 L20, "clayed loamy" should be "clay loam".

OK, corrected.

14. P4 L20, "...and its understory herb layer in a clayed-loamy plain, ...". Please change it to "...and its understory herb layer in a plain of dominantly clay loam soils, ...".

OK, corrected.

15. P4 L25, "clay loamy" and on the next sentence "clay-loamy". Please be consistent about using your terminology and change them to "clay loam".

C6

OK, corrected.

16. P.4, L35, why were you bias about your sampling directions at N-S or E-W, and not to randomly choose the transect direction? Please justify it. 17. P.4, L35,

The N-S or E-W directions were originally chosen for seasonal and long term monitoring of the vegetation canopies (herbs and trees). The corresponding 1 km transects were set perpendicular to the main orientation of the vegetation pattern. For fixed dune systems, it means perpendicular to the dune and interdune succession. Along the 1-km transects, this allows spatial heterogeneity to be taken into account. The choice of the sampling line is described in Hiernaux et al. (2009) and Mougin et al. (2009).

To make it clearer, we modified the text as (P6, L5-9):

“These photographs were collected during the growing season of herbaceous canopies or over the whole year for the forest canopy (Figure 2a, 2c), and regularly taken along one or two perpendicular 1 km sampling transects crossing the site, perpendicular to the main orientation of the vegetation pattern that is perpendicular to the dune and interdune succession, usually in the North-South or the East-West directions (Table S3). Along the 1-km transects, this allows spatial heterogeneity to be taken into account. The choice of the sampling lines is described in Hiernaux et al. (2009).

. Hiernaux, P., Mougin, E., Diarra, L., Soumaguel, N., Lavenu, F., Tracol, Y., Diawara, M.: Rangeland response to rainfall and grazing pressure over two decades: herbaceous growth pattern, production and species composition in the Gourma, Mali. *J. Hydrol.* 375 (1-2), 114–127, doi:10.1016/j.jhydrol.2008.11.005, 2009.

“geolocated” please change it to “georeferenced”.

OK, corrected.

18. P.4, L35, “to within an approximately 10-metre accuracy” please change it to “with approximately 10-meter horizontal positional accuracy”.

C7

OK, corrected.

19. P4, L40, “approximately 100 (50)”? 100 (50) is vague. Please explain it.

We mean 100 photographs for the 1-km transects and 50 photographs for the 500 m transect in the Kelma forest. To make it clearer, the sentence has been changed to:

“At each sampling date, 100 or 50 hemispherical photographs were acquired at the 1 km herbaceous or 0.5 km forest sites, respectively, that is a picture taken every 10 meters.”

20. P4, L40, “herbaceous (forest) sites” is confusing. Please explain it. The term forest in the parenthesis gives readers the impression of equality to the herbaceous.

This has been changed. See above.

21. P5 L5, “. . . maintained horizontal thanks to bubble-levels.” is vague. What does “thanks” mean here? Please rewrite it in a clear way.

OK, we changed the sentence to “maintained horizontally using a bubble-level”.

22. P5 L10, “non green” please change it to “non-green”.

OK, changed.

23. P5 L10, “and has proved to be efficient” please change it to “and has been proved to be efficient”.

OK, changed.

24. P5 L25, “ $\pm 17.3\%$ ” and “ $\pm 36.5\%$ ” are accuracy or standard deviations? If they are standard deviations, please be careful about using your terminology.

These are accuracies estimated for the savannah sites in Mougin et al. (2014). For Kelma forest, the accuracy was estimated in the present study using the same approach as for the herbaceous sites. The corresponding sentence was slightly modified as:

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“The accuracy associated to the field LAI estimates is approximately $\pm 17.3\%$ for the herbaceous canopies (Mougin et al., 2014). Following the same approach and by taking into account the errors of classification and spatial sampling, the accuracy on the Acacia forest PAI is approximately $\pm 36.5\%$ (this study).”

25. P5 L30, “Afterwards, the herbaceous green canopy rapidly dried out apart from the forest understory composed partly with the perennial herb ...”. It is confusing. Please rewrite it in a clear way.

The difference between the vegetation cycles of the sandy sites and the inundated understory comes from the soil moisture conditions and because annual herbs dominate in the sandy sites whereas the forest understory is mainly composed of perennial herbs which exhibit a longer vegetation cycle. The sentence was modified as (P7 L7-9):

“Afterwards, the herbaceous green canopy composed of annual plants on sandy soils, rapidly dried out apart from the seasonally inundated Kelma forest understory, composed partly with the perennial herb *Sporobolus helvolus*, which benefited from more humid conditions.”

26. 5. Use of the data set, P6 L30, this is an objective of this study and needs to go to the end of introduction.

As suggested, this part was moved to the end of the introduction. After the modifications, the section 5 starts by :

“In addition to the documentation of the seasonal, inter-annual and decadal variations of vegetation variables in relation to rainfall variability, examples of data use in validation exercises of remote sensing products and surface models, are briefly presented below.”

27. 4.1. Validation of satellite products, P7, L5, “...the clumping efforts performed thanks to the estimated aggregation factor, ...” what is the meaning of “thanks” here. It is a confusing sentence. Please rewrite it.

C9

We modified the sentence as : “...the clumping effects performed using the estimated aggregation factor, ...”

28. P7 L10, why is “VEGETATION” capitalized? Does it convey a specific meaning here? Please explain it.

Yes, it is because ‘VEGETATION’ is the name of a moderate resolution satellite dedicated to the monitoring of global vegetation. To avoid any confusion, we replaced ‘VEGETATION’ by ‘SPOT-VEGETATION’ as in the Introduction section.

29. P7 L10-15, what does it mean “The collection 6 benefited from improved surface reflectances and biome type inputs (Wolfe et al., 2013), and provided more accurate products (Xu et al., 2018b)”? It is confusing. Why didn’t you compare year by year computed vegetation indices from MODIS imagery and field dataset for 13 years? How do you deal with the yearly fluctuations of precipitation in such an arid climate that significantly impacts the leaf area index and other vegetation characteristics? Based on your analysis, you are assuming the vegetation indices derived from MODIS imagery at the period of 2005-2017 are similar to the period of 2015-2017. I recommend you rerun the analysis using year by year comparison between computed vegetation indices from the MODIS imagery and the field survey.

Sorry for the confusion. We extracted MODIS LAI products that correspond to the exact location of the validation sites and for the date of field observations (± 4 days). Field and MODIS LAI values were then compared together and a statistical analysis was made. Two examples of such a comparison are shown in Figures 5a and 5b for the savannah and forest sites, respectively. Only the MODIS pixels flagged as ‘good’ pixels are retained for the comparison. This explains why we finally kept a limited number of MODIS values in the comparison.

30. P6 L20, please change “meso scale” to “mesoscale”.

The word ‘mesoscale’ has been suppressed in this section.

C10

31. P14, Figure 1, Please make a joint map with this figure that shows the study area in the African continent.

OK, as suggested, Figure 1 has been modified to include a small figure showing the location of the validation site in Mali, within the West African region.

32. P18, Figure 5, the issue of specified comparison of MODIS imagery with field surveys, for vegetation indices, is pretty much clear on the data points where data are clumped row by row, especially in the regression plot for Kelma forest, and this type of comparison is not statistically true and can cause erroneous results.

As explained above, we extracted again the MODIS LAI products and select only those issued from the main inversion algorithm. Then, we reran the statistical analysis. The results of the direct comparison study are shown in the corrected Figure 5:

33. P22, Table 3, Why are almost half of your sampling sites include a very low yearly sample size, e.g., sites no. #17 Agoufou NS, #18 Timbadior NS, #18 Timbadior EW, #31 Tara NW-SE, #40 Eguerit EW, and #41 Bilantao NE-SW, and how do you justify drawing conclusion from the results of such an small sample size? What is the reason for not having enough samples at those sites?

The main reason is the occurrence of the Northern Mali conflict (Mali civil war) that started from 2012. A peace deal between the Malian government and rebels was signed on June 2013, but the region is still very unsecured due to the activities of islamists groups, and various armed groups, sometimes promoted by ethnic rivalities. Moreover, drug trafficking is very active. Accordingly, field work remains very risky, and can only be performed during short periods of peace.

However, from 2005, a total of 658 sampling transects have been monitored, and approximately 52 000 hemispherical images have been acquired, processed and analysed. This data set is of considerable interest in a weakly sampled region strongly impacted by the current global change.

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By having such a small sample size, making conclusion for those sites with specific plant communities and thus a broader conclusion for the entire vegetation communities across the northern Sahel could be questionable.

This data set complements well numerous past and recent studies in the Gourma region (see for instance the papers: Hiernaux et al., 1984; Hiernaux et al., 2009a; 2009b; Mougin et al., 2009 ; Dardel et al., 2014). Associated to vegetation observations collected in other Sahelian countries (for instance in Senegal by the Institute of Geography of Copenhagen, in Niger by the French National Research Institute for Development), the present data set can be very useful to support regional studies at the Sahel scale.

. Hiernaux P., Cisse, M. I., & Diarra, L., 1984. Bilan d'une saison des pluies 1984 tres deficitaire dans le Gourma (Sahel malien): Première campagne de suivi et télédétection expérimentale. Addis Ababa, Ethiopia: ILCA. . Hiernaux P., Lassine D., Trichon V., Mougin E., Baup F., 2009c. Woody plant population dynamics in response to climate changes from 1984 to 2006 in Sahel (Gourma, Mali). *Journal of Hydrology, AMMA CATCH special issue*, 375(1-2), 103-113, doi: 10.1016/j.jhydrol.2009.01.043. . Hiernaux P., Mougin E., Diarra L., Soumaguel N., Lavenu F., Tracol Y., Diawara M., 2009a. Rangeland response to rainfall and grazing pressure over two decades: herbaceous growth pattern, production and species composition in the Gourma, Mali. *Journal of Hydrology, AMMA CATCH special issue*, 375(1-2), 114-127, doi: 10.1016/j.jhydrol.2008.11.005. . Mougin E., Hiernaux P., Kergoat L., Grippa M., et al., 2009. The AMMA Gourma observatory site in Mali: Relating climatic variations to changes in vegetation, surface hydrology, fluxes and natural resources. *Journal of Hydrology, AMMA CATCH special issue*, 375(1-2), 14-33, doi:10.1016/j.jhydrol.2009.06.045. . Dardel C., Kergoat L., Hiernaux P., Mougin E., Grippa M., Tucker C.J., 2014. Re-greening Sahel: 30 years of remote sensing data and field observations (Mali, Niger). *Remote Sensing of Environment*, 140, 350-364, doi :10.1016/j.rse.2013.09.011.

34. Supplements, Figure S2, the picture numbering (the letters) doesn't correspond to

C12

the letters written in the figure caption.

Thank you for noticing. This has been corrected.

35. The type of soils in Table S1 and Table S2 do not look correspond to each other for some sites. For example, Kelma Plain (#21b) site shows a dominant soil type of clay loam in the Table S1 but the percentage of soil particles in Table S2 shows a very low amount of clay particles about 1-2 %. Please check them out and use the common soil textural triangle to find out the soil texture class for every site

Thank you again for noticing. For the Kelma plain, the type 'clay loam' has been changed to 'silt loam' in accordance with the soil textural triangle. The Tables S1 and S2 look correct for the other sites.

Interactive comment on Earth Syst. Sci. Data Discuss., <https://doi.org/10.5194/essd-2018-113>, 2018.

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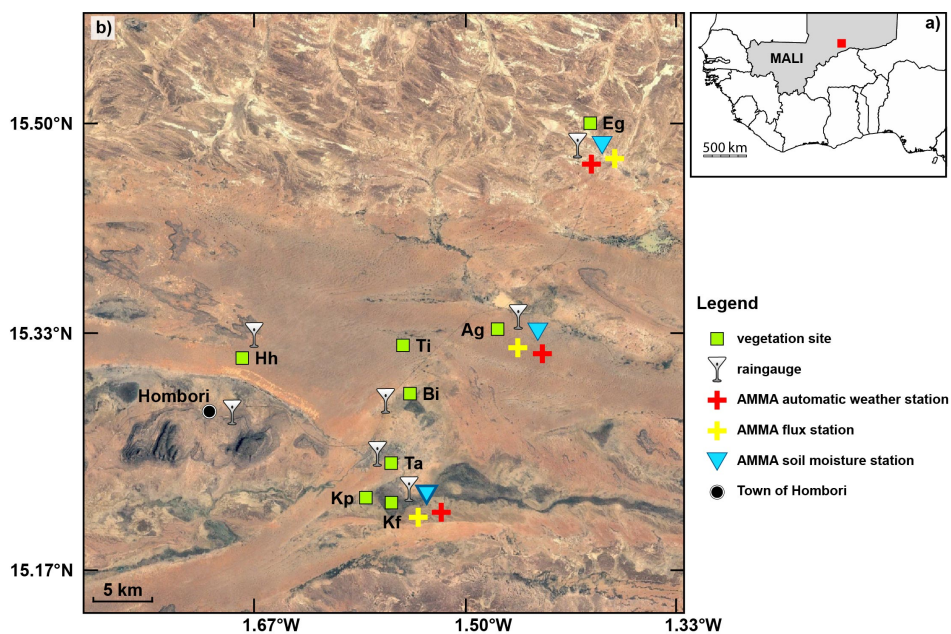


Fig. 1. Figure 1. The validation sites used in this study: a) Location of the 50 km x 50 km AMMA super-site in Mali, West-Africa, and b) map (on a Google-Earth image, 2016/31/12) of the super-site showing the

C14

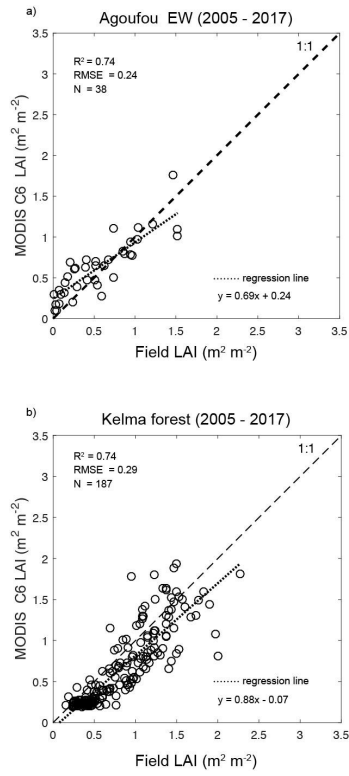


Fig. 2. Figure 5. Comparison between field LAI or PAI estimates and MODIS Collection 6 LAI products for the period 2005-2017: a) Agoufou herbaceous canopy and b) Kelma forest site. In this later case, the MOD