

Interactive comment on “Less rain, more water in ponds: a remote sensing study of the dynamics of surface waters from 1950 to present in pastoral Sahel (Gourma region, Mali)” by J. Gardelle et al.

Anonymous Referee #1

Received and published: 23 September 2009

This manuscript presents a long term study on the water storage in ponds, based on a number of different satellite images and aerial photography acquired over the Gourma Region in Mali. The authors report of a drastic increase in pond surface areas, despite a reduction of rainfall – an observation much in line with the “sahelian paradox” that has been described for that region with an increase of stream flow despite a reduction of rainfall.

While the topic is interesting and important from a scientific and water resources point of view, the manuscript suffers from language problems and has a number of struc-

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tural and organizational flaws. More importantly, however, is that the results of the analysis are not presented adequately, and it is not obvious to the reader how certain conclusions are arrived at as a result of the analysis.

The most prominent concerns are the following:

- According to the authors, 92 ponds were analyzed. However, only the results from two such ponds are presented (Agoufou and Ebang Mallam) at greater, but still limited, detail. Much of the authors’ argumentation is based on the presented data from these two ponds. In the context of lake turbidity in ponds the authors state on p. 5063, l.12-14 “[. . .] and, like in the case of Agoufou, expansion of the watershed by capture of a neighbor watershed that till the late 1980’s was only feeding the ponds of Sabangou and Taylalelt.” Information on how much the catchment of the Agoufou pond expanded are not presented. It is not apparent how observations from this pond are used to argue that the flood regime of ponds started to change in the late 1980’s (i.e. stated in p. 5048, l. 15-17, or p. 5067, l. 13-16) and attribute this to the effect of droughts on herbaceous and woody plant vegetation over shallow soil (p. 5067, l. 26- p. 5068, l. 2). Even though there are only a few satellite images available from the 1970’s and 1980’s (Landsat MSS and Landsat TM, see Table 1), the results from these images are not shown anywhere. There is also no other line of argumentation, i.e. drawing on different research, that would allow coming to the conclusion that a change can be pinpointed to the late 1980’s.

- P.5062, l. 18-20 reads: “Despite the overall 98% surface increase between 1975 and 2002, 17 ponds had no flood increase, and the rate of increase of the other 75 significantly varied between ponds.” There is no presentation of any of these results and no more information on the variation observed in the 75 ponds that showed an increase in surface area over time. It is unclear why this information is withheld.

Specific comments

p. 5048, l. 9-11: “The high-frequency MODIS data document the seasonal cycle, with

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an abrupt rise early in wet season and a progressive decrease in the dry season.” Please specify what the abrupt rise refers to.

p. 5048, l. 27- p. 5049, l 1: “Instead, major responsibility is attributed to increased runoff triggered by the lasting impact of the 1970–1980’s droughts on the vegetation and on the hydric system over shallow soils.” The first part of the statement is not arrived at through thorough analysis in the manuscript. If this statement is to be made, the authors should provide sound reasoning for this statement.

p. 5048, l. 27- p. 5049, l 1: “[. . .] and on the hydric system over shallow soils.” It is not entirely clear what the term “hydric system” (also p. 5051, l. 25, p. 5063, l. 10 and l. 15, p. 5068, l. 1) refers to (hydric soils?). A variation is the term “hydric web” (p. 5052, l. 9 “The position of the pond along the hydric web, [. . .]”) which is also unclear.

p. 5050, l. 4: period is missing at the end of the sentence.

p. 5050, l. 5-6: “The aim of this work is to document and discuss the evolution from the mid twentieth century of surface water in the pastoral region of Gourma, in Mali.” Should be “The aim of this work is to document and discuss the evolution of surface water from the mid twentieth century in the pastoral region of Gourma, in Mali.”

p. 5050, l. 26: “. . .used to outline water level in ponds. . .” should be “. . .used to outline the extent of surface areas of ponds”

p. 5051, l. 13-16: “Indeed, rainfall of most years from 1970 onwards stand below the average over the whole series ($375.2\text{mm} \pm 110.8$ from 1936 to 2008) with average rainfall dropping of 20% prior (422.2mm) and since (336.2mm) 1970.” should be “dropping by”. Please also rephrase the sentence to clarify

p. 5053f, Subsection “Data”: There is no description of the precipitation data.

p. 5055, l. 12-14: It should be explained why the NDPI can separate aquatic vegetation from adjacent, land based vegetation.

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p. 5057, l. 6-9: ” The average values of the NDPI and the MIR band within this region were then computed, and a tolerance was applied to those values to define the thresholds used for the classification (namely ± 0.1 for the index values and $\pm 5\%$ for the reflectance values)” What are these values based on?

p. 5059f: Section “Results”, general comment: The result of the analysis of the 92 ponds is largely absent, except for some detail that is given for two selected ponds. It is essential to present much more of the results if the reader is to be convinced of the later conclusions. (What is the size of these ponds? Temporal dynamics? . . .)

p. 5059: Subsection 4.1 “Assessment of the classification”: This section is under “Results”, but it contains mostly the methodology. The methodology should be extracted and presented under section 3 (Methodology).

p. 5059, l. 10-13: “For LANDSAT TM and ETM, images, the accuracy of the maximum likelihood classifier is evaluated by comparing classified data with an independent set of well characterized areas resulting from field studies (Hiernaux unpublished).” Please clarify what the well characterized areas are.

p. 5059, l. 16- p. 5060, l. 9, general comment: MODIS data makes up the largest number of images this study is based on (366 images, Table 1), but the accuracy assessment is described rather vague, although it is described as difficult. Please be more specific, i.e. when the size of the ponds decline, what ratio of mixed to pure pixels do we end up with (maybe to be compared to this ratio for a full pond).

p. 5060, l. 6-7: “[. . .], which concluded that surface estimation is accurate above a given threshold of a few ha or tens of ha, allowing pure pixels to be present.” This is too vague. If you have used a threshold you need to present a specific number.

p. 5060, l. 23-25: “Only a few (Gossi, see Fig. 2 also Benz’ema, which is west of the LANDSAT scene) were permanent until the 1990’s (Ag Mahmoud 1992) but since, additional ponds (Agoufou, Ebang Mallam for example) became permanent.” Please

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specify: How many are a few? And how many are a few more?

p. 5061, l. 4-6: "The variations of the surface of the Agoufou pond inferred from 2000–2007 MODIS data (Fig. 7) show a linear relation with precipitation." What is the r^2 of the linear relationship?

p. 5061, l. 9-13: "However the values of the pond's surface do not appear to be widely scattered over the last 10 years: for cumulative rainfall ranging from 300mm to 400 mm, the surface of Agoufou pond falls between 150 ha and 230 ha and Ebang Mallam (not shown) falls between 300 ha and 450 ha." Why are the results from Ebang Mallam not shown?

p. 5061, l. 15-18: "The analysis reported above provide a range of seasonal values of the flood surface of the ponds that allows the interpretation of their comparison with the few data available for the historical period (single points in Fig. 6). Each historical data can be compared to pond's surface at the same time of year and for similar rainfall amount." The part ". . .and for similar rainfall amount" is only possible in connection with Figure 7 (also indicated in the following sentence). However, because the size of the contributing area of the Agoufou pond changed during the period of observation, the conclusiveness of the results are limited. Data from Ebang Mallam which could back the argument is not shown in Figure 7.

p. 5062, l. 2-6: "The swelling of the ponds flood do not match the onset (early 1970's) nor the peak of the drought (mid 1980's). It did not coincide either with the wetter years of (1991, 1994, 1996 and 1999) but preceded them, starting in the late 1980's with open water remaining during the whole dry season in both ponds from 1990 onwards." There is no evidence given that would support the argument that a change to the late 1980's. Please explain how you pinpoint the start of a regime change without any data shown.

p. 5062, l. 9: "The supervised classification of flooded and moist soil surface in September 1975 and [. . .]" Several questions arise in relation to this sentence. A) it

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is not clear why the classification of moist soil surfaces is pointed out here. Is moist soil included in the pond area? If remotely sensed moist soil surfaces are relevant in this study (i.e. in relation to runoff production, etc.), please describe it and explain its classification in the methodology section. B) It mentions the year 1975 – there no data shown for 1975 in any of the graphs.

p. 5062, l. 9: "All together, the flooded area of these ponds reached 12 441 ha in 1975, 20 321 ha in 1999 and 23 119 ha in 2002, thus an overall increase by 98% over the 1975–2002 period of time. The following analysis focuses on the 2002– 1975 paired classifications, since these two years are closer in terms of precipitation and span a longer time-period." If we believe Figure 1, then the years 2002 and 1975 are quite different (1975 ca 150mm above average, 2002 ca. 50mm below average) – in terms of precipitation, the years 1975 and 1999 are closer. Please correct.

p. 5063, l. 9-14: "This is due to a structural modification of the hydric system with the shortcut of some of the relay ponds upstream, acceleration of the flood speed by deepening of the channels, [. . .]" Apart from the need to clarify the term "hydric system", what evidence are these statements based on? The sentence continues "[. . .] and, like in the case of Agoufou, expansion of the watershed by capture of a neighbor watershed that till the late 1980's was only feeding the ponds of Sabangou and Taylalelt." It is not clear to me why a pond was selected as the most prominent example that had an increase in contributing area during the period of observation. If there is an explanation for it, the reader should be informed of this much earlier in the text so that this aspect can be taken into account in reviewing the analysis.

p. 5064, l. 2-3: "When using coarse resolution images (MODIS), a critical size was identified." Please state this minimum size.

p. 5064f, Subsection "A paradoxical dynamics": Referring to the title of the manuscript I would expect most of the interesting results condensed and discussed in this section. However, this section is a little detached from the rest and not easy to follow. I under-

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stand that the authors point out differences observed in “blue” and “red” ponds, but I don’t see the conclusion of the discussion. I suggest the authors re-write this section, or combine it in a clearer form with section 5.3.

p. 5066, l. 19-23: “While the vegetation of rangelands set on sandy soils and on lowland clay soils monitored in the Gourma revealed very resilient to the drought, with a fast regeneration (2–5 years to reclaim production) of the herbaceous layer and a slower one for woody plants (10–25 years to reclaim production), that of the shallow soils did not recover from the drought 25 years later.” Please give evidence/a reference, especially for the last part of the sentence.

p. 5067, l. 22- p. 5068, l. 2: “The causes of the changes in flood regime of ponds are discussed in relation to their geographic location, the particularities of the watershed feeding them, and the dynamics of the radiometric characteristics of their flood. The possible impact of cropland expansion and intensification of forestry and pastoral use are discussed and considered secondary. Instead, it is argued that the lasting impact of the climatic droughts of the 1970’s and 1980’s on the herbaceous and woody plant vegetation over the shallow soils on rock and hard pan outcrop, and its consequences on the hydric system, are the main causes of this spectacular phenomenon.” With reference to the previous chapters I don’t feel like I experienced a thorough, well structured, and conclusive analysis and discussion of the causes of the changes of the flood regime. Several aspects were mentioned, but not discussed at depth. An additional shortcoming is the lack of presentation of results from the 92 ponds which were part of this analysis. With well over 400 satellite images and aerial photographs at hand it is surprising that no effort was made to evaluate whether the herbaceous and woody plant vegetation over the shallow soils on rock and hard pan outcrop were affected by drought to such an extent that an increase in runoff from these degraded areas can explain the drastic increase in pond size.

Figures:

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Almost all figures contain illegible text. Text size needs to be improved and figure size increased to give the reader the chance to study the presented information.

Additionally:

Figure 2: state date and band combination of the image acquisition. It is not explained what the N-C and C-S lines are, and how they were determined.

Figure 4, 5: Figures are too small. Especially the line graphs are not legible at all.

Figure 6: Figures are too small, graphs not legible. It should be indicated what kind of satellite images are shown. “Up” and “Down” should be replaced by “a” and “b”.

Figure 7: add a trend line to show the linear relationship and highlight the data points used (data points from 2000-2007), show r^2 . The data point in the lower right corner has no date label. I would encourage the authors to add the data from the Ebang Mallam pond.

Language:

The language of the manuscript should be reviewed.

At his point I just want to point out some recurring mistakes:

- “Ponds area” or “ponds’ areas” should be “pond areas” or “areas of ponds”
- Most sentences containing “which” need to be corrected, i.e. p. 5050, l-25-29; p. 5052, l. 4-9; p. 5052, l. 23-26; p. 5064, l. 5-9 and l. 28.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 6, 5047, 2009.

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