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Interactive comment on "Analysis of Land surface Temperature change based on MODIS data, Case study: Inner Delta of Niger" *by* Abdramane Dembélé et al.

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1) The authors thank the reviewer for thoroughly reviewing our manuscript, providing valuable suggestions to improve the manuscript. It convenient that this study focuses on the analysis of the temporal variation of LST values in order to estimate the spatiotemporal-effects on environment during 18 years. Accordingly, a common response has been prepared for this part concerning the objective and other data sources such as lithology, hydrological, and Rainfall.

The MODIS image is a good indicator of Land surface temperature (LST) on the interface analysis in order to characterize areas. The latest decades has registered the attraction of much attention through the LST at large-scale (Roy et al., 2014; Vlassova, Pérez-Cabello, Mimbrero, Llovería, & García-Martín, 2014; Wang, Liang, & Meyers, 2008; Zorer et al., 2013) and the advancement of earth and environmental sciences in the desertification monitoring so as in the monitoring of LST evolution (Hillger & Clark, 2002a, 2002b). One of the major driving forces causing many extremes of soil anomalies whose in recent years that many regions have undergone is the terrestrial global warming (C et al., 2013; Committee, 2015; Tol, 2009). Based on meteorological stations data, many studies have quantified the global temperature of the earth (Coumou, Robinson, & Rahmstorf, 2012; Frangou, Ladle, Malhado, & Whittaker, 2010; Rahmstorf & Coumou, 2011). Then several phenomena and climate extreme have been recorded during 2011–2015 and the probability increased by a factor of ten or more, in the case of some extreme high temperatures (World Meteorological Organization, 2016a)(World Meteorological Organization, 2016b). Only temperature anomalies have concerned most analysis(Report, 2018; Weber et al., 2014). The Inner Delta of Niger (IDN), in central of Mali, through desert regions represents one of the hot areas of the African plate (Friese, 2010; Mao, K et al., 2017). Inner Delta of Niger, is part of a large geological structure (Continental Terminal, Precambrian, Quaternary) that have played several roles since the Pan-African Orogeny and may present a risk of current activities (Inger, Dione, Jarosewich-Holder, & Olivry, 2006), (El Abbass et al., 1993). Certain portions of the region are superimposed on an area of positive gravity anomalies (Svensen et al., 2003). The parallelism between the gravity and structural directions is particularly marked between Tombouctou, Faguibine and the Nara Trench (Chudeau, 2018; Leo Zwarts, Van Beukering, Kone, & Wymenga, 2005). In April 2001, has been receiving reports about increased thermal activity in Tombouctou area (Svensen et al., 2003). Hot fumaroles and magmatic rocks whose the upper part of a hydrothermal system has been observed and considered as volcanic activity (Villatte, 1973). This study focuses specifically on multitemporal analysis of LST by a set of processes while also emphasizing the variation of LST values under the influence of different sectors as well its effects on environmental lithology, hydrological, Rainfall and others.

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The climate variability and the hydrological regime It was calculated before 1923, the maximum flood levels from the relationship between the average monthly flow measured at Koulikoro in September. Based on daily measurements of the water level as shown the Figure 7, the Mopti area receives the peak of the flood in 1929, then Akka and Dire around 1957. From there, a gradual decrease in the water level until 1984 (year catastrophic dry) is observed, which reduced the flooded area to 7800 km2 against 22.000 km2 during the years that preceded. Between 1994 and 2012, the maximum floods that never reached the previous peaks, vary very randomly with slight regressions of the peak levels (Sangaré, S., Mahé, G., Paturel, J.-E., et BANWURA, Y, 2002; L. Zwarts & Hoekema, 2013). The dates of the maximum flood have returned to near the 70s at the beginning of the drought, but remain earlier than during the wetter years before 1970 (at least 1.5 months) (Zaré, 2015). The cumulative volume at the exit (outlet) of the Inner Delta in Diré region during the period from June 1, 2015 to April 30, 2016 is 27.79 109 m3. This volume is higher than that of 2014/2015 (25.74 109 m3) and lowest than that of 2013/2014 (32.87 109 m3) and that of statistical mean from 1924 to 2012 (30.38 109 m3) (Niger Basin Authority, 2016). The effect of terrestrial warming represents one of the potential factors of the decrease of the water level in the different sectors, it is also observed on the images and statistics of the LST through the progressive variation of its values.

LST and the geology The characteristic of the LST shape is further builted as based on the continuous and smooth modelling. Figure 6 illustrates the 3D format of the Mean of 18 years. The morphology of the modelling is well described over the geology (lithology) area (Dembélé & Ye, 2017; Mahe, Orange, Mariko, & Bricquet, 2011; Maiga. H, Marie. J, Morand. P, N'Djim. H, 2007). The diversified mean LTS values "from 19.21°C to 48.94°C" show from the geology and landscape configuration an appreciable demonstration. The morphological typical shapes such as concave, ridge, and flat part are illustrated in Figure 6 by taking the mean as an example. The three regions has revealed that the LST values of hottest areas are represented by the mountain ridges (the highest), while the lowest temperatures are illustrated by concave cavities, and fol-

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lowed by the mean temperatures which are illustrated by flat shapes. Accordingly the modelling, the first region performs as a concave shape as a water area surrounded by wet area included between "19.21°C to 31.10°C" in the recent alluviums (Figure 7) Also a semi-dry area, the second region demonstrates as a flat part between "31.10°C to 43.00°C" at southwest into the arrangement of Ancient alluvium and continental terminal formations, at South-east into the Precambrian and at a small part of north over the dunes and sandy area. The third region reveals a ridge morphology in a mixed Dunes, sandy, clays, and laterite at the northwest of the study area include between "43.00°C to 48.94°C". Therefore, the diversification of the geology also influences the values of the LST as the modeling.

LST, rainfall and geology This continuity phenomenon of terrestrial warming tends to increase the water resources needs by affecting of the different systems of aquifer existing in the study area. From the rainfall point of view, precipitation decreases have been observed since the end of the 1950s which has been exceptionally high, and then the last three decades of the period 1961 to 2004 (Ministere De L'equipement Et DesTransports-MALI, 2007; Zwart, 2010). The isohyets of the 1981-2010 normal (Figure 7b) are characterized in the Saharan and Sahelo-Saharan zone of Mali by a slight rise towards the North-East compared to the normal 1961 - 1990 (Figure 7a) (Gicresait, 2017). In the set, the influence of LST values caused by warming contributed to the variability of precipitation. Consisting of three major aquifer systems, the major part of the study area is occupied by the generalized aquifers consisted of the continental terminal/quaternary or Intercalary stratigraphy. They are characterized by the permeability of intergranular types and by a continuous aquifer. Consisting of the Precambrian tabular/folded stratigraphy representing the second big area, cracked aquifers have a low permeability. They are endowed with water reserves from other environment through deep cracks, so these aquifers receive more drillings than any others aquifer system. The superficial aquifers being recent formations is consisted only of the quaternary stratigraphy, then play an important infiltration role because of its non-consolidation. All of these aquifer systems today continue to receive more drilling

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2) The authors thank the reviewer for thoroughly reviewing our manuscript, providing valuable suggestions to improve the manuscript. Therefore a language review has been made to the entire manuscript after all corrections addressed in the following paragraphs including the add of new source of data for disasters assessments. After an assessment of the - Trends and variations in minimum, maximum and mean temperatures observed, the impact on the hydrological regime by climate variability has been carried and evaluated. It was calculated before 1923, the maximum flood levels from the relationship between the average monthly flow measured at Koulikoro in September. Based on daily measurements of the water level as shown the Figure 7, the Mopti area receives the peak of the flood in 1929, then Akka and Dire around 1957. From there, a gradual decrease in the water level until 1984 (year catastrophic dry) is observed, which reduced the flooded area to 7800 km2 against 22.000 km2 during the years that preceded. Between 1994 and 2012, the maximum floods that never reached the previous peaks, vary very randomly with slight regressions of the peak levels (Sangaré, S., Mahé, G., Paturel, J.-E., et BANWURA, Y, 2002; L. Zwarts & Hoekema, 2013). The dates of the maximum flood have returned to near the 70s at the beginning of the drought, but remain earlier than during the wetter years before 1970 (at least 1.5 months) (Zaré, 2015). The cumulative volume at the exit (outlet) of the Inner Delta in Diré region during the period from June 1, 2015 to April 30, 2016 is 27.79 109 m3. This volume is higher than that of 2014/2015 (25.74 109 m3) and lowest than that of 2013/2014 (32.87 109 m3) and that of statistical mean from 1924 to 2012 (30.38 109 m3) (Niger Basin Authority, 2016). The effect of terrestrial warming represents one of the potential factors of the decrease of the water level in the different sectors, it is also observed on the images and statistics of the LST through the progressive variation of its values.

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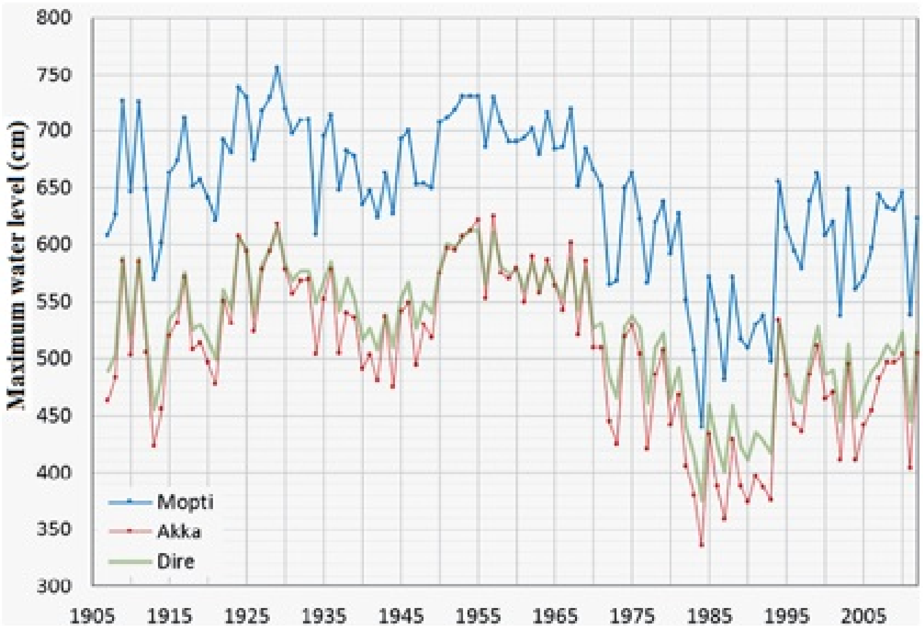

Figure 7 The annual variation of the maximum water level in the Inner Niger Delta (L. Zwarts & Hoekema, 2013 - Mali DNH data)

Fig. 1.

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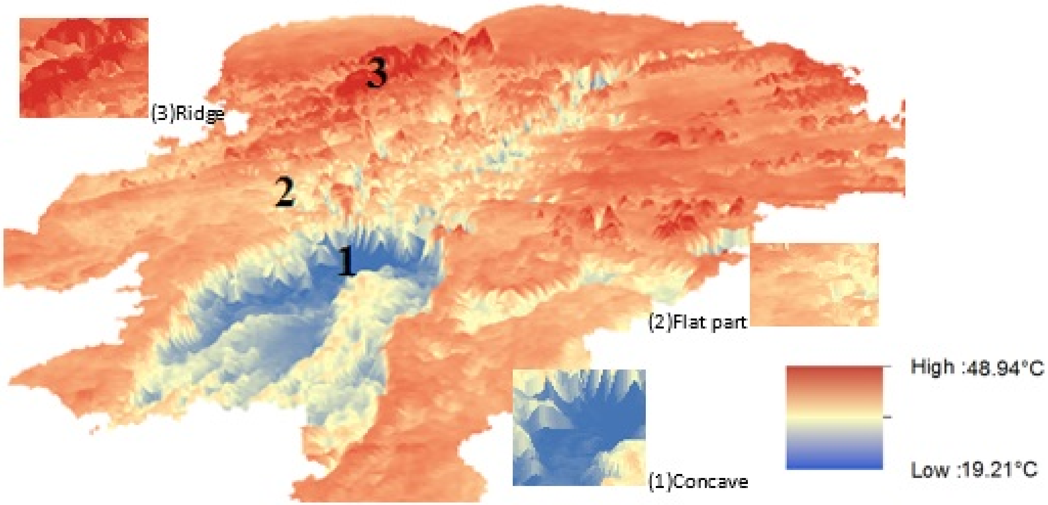

Figure 8. Modelling of the mean LST

Fig. 2.

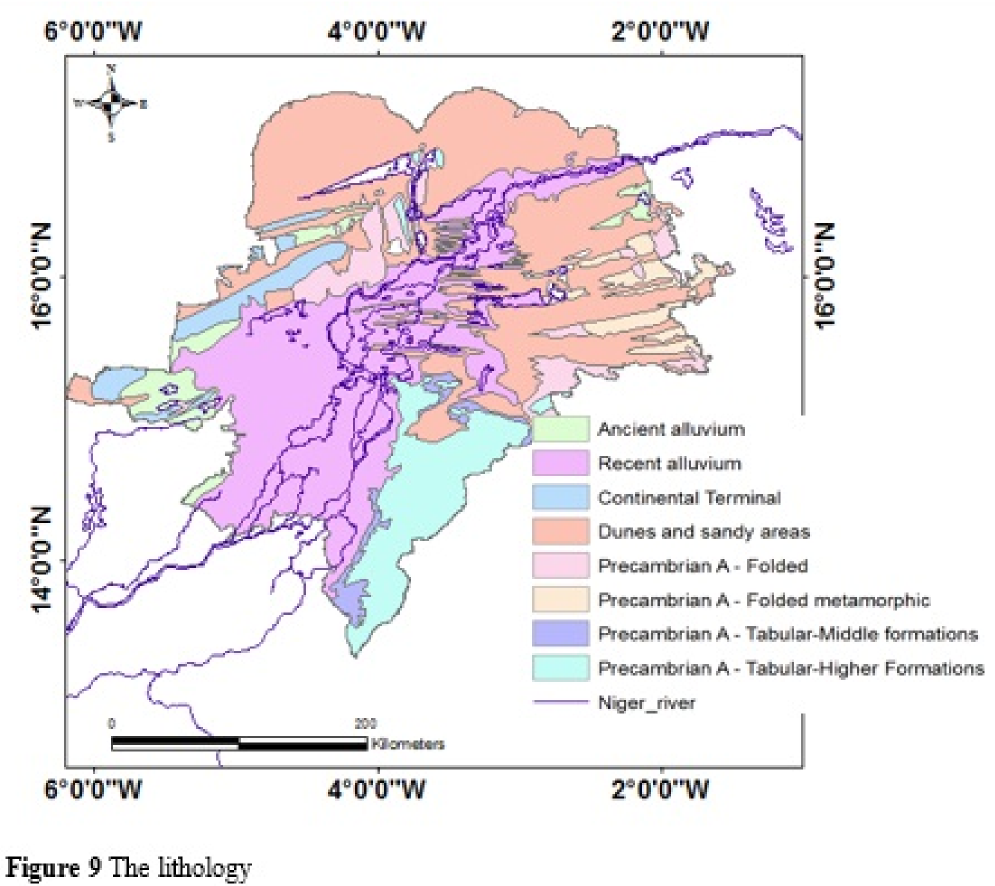

Fig. 3.

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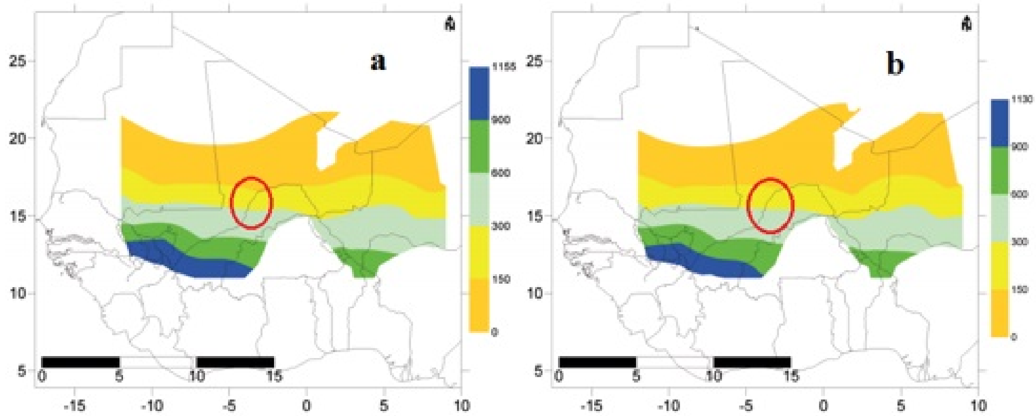

Figure 10 Representation of the isohyets; (a) Normal 1961_1990; (b) Normal 1981_2010 (Gicresait Projet; Sahara and Sahel Observatory; 2017)

Fig. 4.

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