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Climate of the Past Discussions

Interactive comment on "Holocene changes in African vegetation: tradeoff between climate and water availability" *by* C. Hély et al.

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Montpellier, the 19th of February 2014

Dear Editor,

Please, find below our response to both reviewers (Rachid Cheddadi being the first reviewer and Philipp Hoelzmann being the second one to respect chronological reviews) as well as yours. We hope these changes and explanations will fulfill your expectations and that our manuscript will satisfy the Climate of the Past requirements to be soon published.

Sincerely yours,

Christelle Hély

———————- Response to reviewer #1:

We accepted the suggestion of moving the last introduction paragraph to the Material and Methods 2.2 section. We therefore put the moved sentences just after the call of Table B1 (corresponding to the Supplementary Information Table S2) starting on page 4 line 1.

Regarding the number of 14C dates and temporal range comments: In areas under predominantly arid conditions, the preservation of lacustrine sediments and of pollen grains is extremely rare, which may explain why some sites can correspond to a single sedimentary sample, as noted by the reviewer, particularly in the central part of the Saharan desert. We agree that this is a major limitation of any landscape/vegetation reconstruction in this area. However, in this synthesis we have systematically only used the dated levels; such approach is conservative but has the advantage to do not induce overrepresentation of taxa or assemblages that have been stable over a given period bounded by two 14C dates by repeating them all over that period. Moreover, the total number of studied levels is still quite high to perform statistical analyses. The table A1 gives all the site and sample information required and we think that this table is more informative (temporal range) than any colored squares on the map in Figure 1.

Regarding the hydrological data comment: All the hydrological data come from Lézine et al. (2011) and are available from the NOAA paleoclimatic database. Therefore we consider that reader can easily access to these data.

Comment on ecological affinities: We agree with the comment on "ecological affinities" and have therefore changed "ecological affinities" by "phytogeographical affinities" throughout the manuscript such as in the title of subsection 2.2 "Analysis of pollen taxa phytogeographical affinities (sensu White 1983) and biodiversity indexes", and in the

Table B1 caption.

Comment on the pdf methodology: The Kuhl et al (2002) paper refers to the presentation of the pdf method. In our study the both sets of data (paleohydrological and pollen) were considered separately and were projected on a 2-dimensional space (latitude and time). As both datasets are representative of western Africa with information covering the Holocene period, their respective spaces could be superimposed. We have absolutely not interpolated data, nor executed inquiries from hydrological location to pollen data, nor conversely. Therefore we modified the sentence and added an extra one to better explain (page 4, lines 18-23) as follows : In parallel, we used the R Ash library (Gebhardt, 2009) to compute the probability density function (pdf) (Kühl et al., 2002) of each dataset (pollen and hydrology, respectively). To proceed, record presences of a given dataset were first split into bins to configure a two-dimensional (time and latitude) space. Then, the default Ash package setting with a five-bin window was used to compute the presence record distribution within such spatio-temporal space.

We agree with the "diversity" comment, and we therefore replaced "diversity" by "richness" on page 1 line 24, page 6 lines 3 and 10, and page 7 line 13 and 15.

We agree with the "aridification" comment, and we therefore corrected on page 6 line 14 as follows: ". . .the overall aridification of the tropical forest environment"

———————- Response to reviewer #2:

Page 6398 line 23: reference added (now on page 2, lines 6-7)

Page 6399-6400: same suggestion as from reviewer #1 to move sentences to the material and method 2.2 subsection: moved.

Page 6400 line 6: the exclusive Sahelian taxa comment: We added the following sentence on page 4 line 11: "It is worth noting that there are only four exclusive taxa in the Sahelian group (SI Table S2)." Regarding the interpretation see below

Page 6400 line 19: Dealing with the dates reported for each fossil site, we confirm that

we have checked them for this revised version, and conversely to what the reviewer has mentioned, the "El Atrun" site reported by Jahns in 1995 presents only one 14C date in the original reference.

Page 6400 line 24: we added the two locations at the end of the sentence as follows (starting on page 3 line 15 of the revised version: ". . . (the Western Sahara in NE Mauritania, and the Eastern Sahara in both eastern Libya and eastern Chad)."

Page 6401 lines 5-8: in order to synthetize the information and avoid repetition we modified the end of the introduction section as follows (starting on page 2 line 29 of the revised version): Pollen taxa have been grouped into four main phytogeographical groups (Guineo-Congolian, Sudanian, Sahelian, and Saharan, respectively) in order to show the broad-scale changes of the vegetation distribution though time. The remaining sentences that were presenting in more details the four phytogeographical groups were translated to the Material and Method 2.2 subsection (starting on Page 3 line 22) as follows: All pollen taxa were classified according to the phytogeographical affinities (SI Table S2) of their source plants (Vincens et al., 2007) and four groups were analyzed :1) the Guineo-Congolian group, mainly composed of humid (semi-deciduous or evergreen) forest taxa growing under 1500 mm annual rainfall or more today (Trochain, 1940;White, 1983), 2) the Sudanian group, primarily composed of dry forest, woodlands, and wooded savanna taxa (500-1500 mm/year), 3) the Sahelian group, composed of grassland or wooded grassland taxa (150-500 mm/year), and finally 4) the Saharan group, composed of steppe and desert taxa (<150 mm/year) and presented here for information only (SI Table S2).

Page 6401 lines 13-16: as also requested by reviewer #1 and already explained above, we have modified the end of the 2.2 subsection in order to provide more details on the probability density function methodology. Changes are as follows (starting on page 4 line 18 of the revised version): In parallel, we used the R Ash library (Gebhardt, 2009) to compute the probability density function (pdf) (Kühl et al., 2002) of each dataset (pollen and hydrology, respectively). To proceed, record presences of a given dataset were

first split into bins to configure a two-dimensional (time and latitude) space. Then, the default Ash package setting with a five-bin window was used to compute the presence record distribution within such spatio-temporal space.

Page 6401 line 16: the Gebhardt 2009 reference has been added to the reference list

Pages 6401-6402 line 25 to 5: Dealing with the comment on the Sudanian group, we agree and changed the sentences as follows (starting on page 5 line 1): Their maximum potential extension reached 25°N during the Early-Holocene, then gradually moved toward southern latitudes after 7.5 cal ka BP, with a slower rate after 4.5 cal ka BP. Meanwhile, the core area of the Sudanian group resisted longer and Sudanina taxa only started to retreat southward after 2.5 cal ka BP. Dealing with the comments on the Sahelian group, it is true that the maximum number of records is likely located around 19°N, mostly based on three records from Mauritania (site #13 spanning from ca 1800 to 3600 BP), Chad (site #48 spanning from 0 to 6000 BP) and Sudan (site #41 spanning from ca 5000 to 10000 BP), therefore covering both the Holocene and several areas along the longitudinal gradient from West to East. There are also quite numerous records southward, over the 13-16°N region, which cover, but more episodically, the Holocene period. Despite such southern distribution, the southern boundary of core zone (centered on 19°N) is located around 15°N. We agree that for the exclusive Sahelian taxa, the fact that there are only four exclusive taxa may induce a bias for the location of their exclusive core zone (comment associated to Table B1), but this cannot be a valid explanation for the non-exclusive taxa as 44 taxa are Sahelian (or Saharan) and distributed all over the spatio-temporal space (at least since 10 000 BP and from 10 to 25°N). Actually, the most interesting point about Sahelian taxa is the northernmost boundary of their maximum extension area that matches with the maximum extension of the lacustrine area, which was computed from independent data. This shows that Sahelian taxa, even though they tolerate well arid conditions they better grow when/where water is available even from a seasonal climate, and therefore it also explains why their core zone is centered on 19°N, which is still further north than

the Sudanian taxa extent, which also tolerate seasonal climate but less pronounced than Sahelian taxa. Therefore in order to better present and interpret the Sahelian taxa distribution, we modified the sentences as follows (starting on page 5 line 5): The distribution of the Sahelian group strongly differed from the two others with a stable core area centered at 19°N since Mid-Holocene (Fig. 2)). The maximum extent of this group clearly follows the maximum extent of lacustrine area during 6000 years (from 11 to 5 cal ka BP), with a rapid northern expansion until 9 cal ka BP followed by a stable period of 1500 years, then a southern retreat starting from 7.5 cal ka BP onward. The slower rate of the retreat recorded after 5 cal ka BP is likely a statistical artefact due to the presence of a single sample (site #8 see SI Table S1). Despite such spatio-temporal bias toward the end of the Holocene, our results clearly show that Sahelian taxa were always present in the whole Sahara and Sahel during the Holocene.

Page 6402 line 6: we agree and modified as follows (starting on page 5 line 14 of the revised version): The core area of both the lacustrine and palustrine hydrological records closely matches the maximum extent of the non-exclusive Sudanian group (Fig. 2).

Page 6402 line 29: corrected here and to some other places such as on page 6 line 9.

Page 6403 lines 1-13: Regarding the comment on Fig.3, we agree and therefore have added the following general sentences at the beginning of the paragraph (page 6 lines 2-8): The regional analysis shows overall temporal trends in all latitudinal zones such as (i) the rapid increase in both richness and abundance of all groups in Early Holocene (13-11 cal ka BP) signing the African monsoon onset and intensification, (ii) rapid changes but with vegetation recovery over the 10-6 cal ka BP period signing the optimum of the African Humid Period, (iii) the simultaneous abrupt changes around 4.5 cal ka BP, likely signing the termination of the monsoon intensification, with different trends among zones and among groups. Regarding the comment on Fig.4, we didn't add extra sentences as we think the monsoon pattern is clearly inferred using the both exclusive pollen taxa type, and that we refer to the Texier et al (1997) paper. We think that extra

interpretation related to the oscillations of humid surfaces that were performed on the Lézine et al. (2011) reference cannot be done here based on the few exclusive pollen taxa present.

Figures and Tables

Fig.1. The reviewer suggest that the two maps should cover exactly the same area, and that we should therefore change map B. However, we prefer to keep these two maps as they were submitted because from the pollen-vegetation map (map A), it is obvious that phytogeographical zones for Guineo-Congolian forests and savannas are today far south compared to the southernmost fossile samples (both pollen and palaeohydrological data. We suggest to explicitly mention it if the figure caption as follows: It is worth noting that modern phytogeographical zones of Guineo-Congolian forests and Sudanian woodlands and savannas are far southern than the southernmost hydrological fossile sample (and also pollen sample). Finally, regarding the map A as requested we changed for colored vegetation type settings

Fig. 2. As suggested, for the palaeohydrological pdfs we changed the grey shadings for blue and green shadings for lacustrine and palustrine status, respectively. Core areas (isoprobability =0.5) have darker colors than the maximum extensions (isoprobability =0.85). Moreover, grey points, representative of pollen samples, were put in black and the isoprobability curves were colored based on the White (1983) map colors, so with the Guineo-Congolian group in blue, the Sudanian one in green, the Sahelian group in orange, and we set the Saharan group in black (in the supplementary figure) . Ticks representative of 5, 10, and 15 cal ka BP are now twice longer than the others (minor ones). Regarding the time axis length, they end at 16 cal ka BP because the palaeohydrological data cover a time window spanning from 0 to 15.5 cal ka BP, therefore imposing the overall range for both analyses in term of graphs. Having taken into account all these aforementioned changes, we finally increased the final size of the figure and reported its caption to the next page. However, we prefer to keep each panel in a quadratic form as in the submitted version.

Fig.3. we used colors instead of greys.

Fig.4: we agree and have therefore changed the sentence related to humid conditions as follows : Humid surfaces refer to the maximum extents of lacustrine and palustrine conditions estimated from the 0.85 isoprobability space at each 1000-year time interval. Moreover, we have also replaced greys by colors, respecting the above conventions.

Fig. C1: As the emphasis of the present study was on the effect of the monsoon (amount and seasonality) and surface water availability reconstructed in terms of lacustrine and palustrine environments, we assumed that Guineo-congolian taxa would be sensitive to seasonality changes within heavy rainfall patterns, while Sudanian and Sahelian taxa would sign the presence of rainfall seasonality in more and more dry environments, respectively. As Saharan taxa characterize the driest environments and grow in areas that do not receive monsoon rainfall, we assumed they were less interesting for the present study but we chose to present them in the supplementary information for fair research transparence.

Table A1: we have checked all the references and we modified the site names to be reported in capitals.

Table B1: see comment above associated to the comment on pages 6401-6402 lines 25 to 5.

Please also note the supplement to this comment:
http://www.clim-past-discuss.net/9/C3489/2014/cpd-9-C3489-2014-supplement.pdf

Interactive comment on Clim. Past Discuss., 9, 6397, 2013.

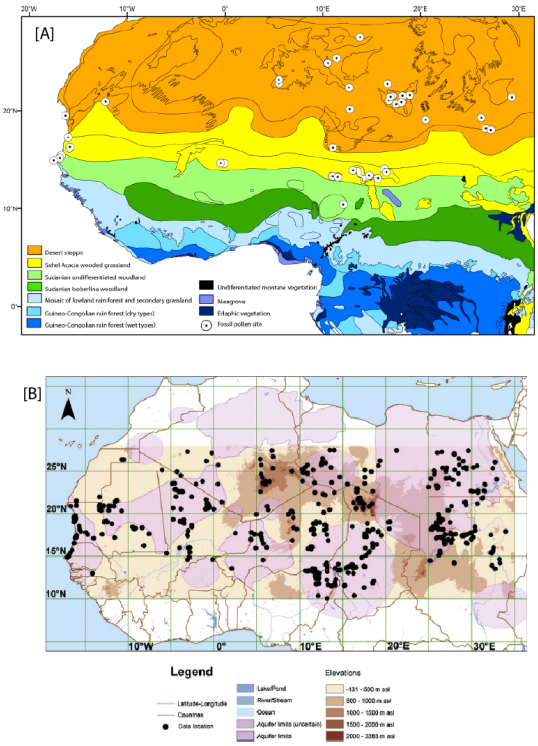

Fig. 1. Location of Western African sites over study area. [A] fossil pollen samples and [B] fossil paleohydrological samples

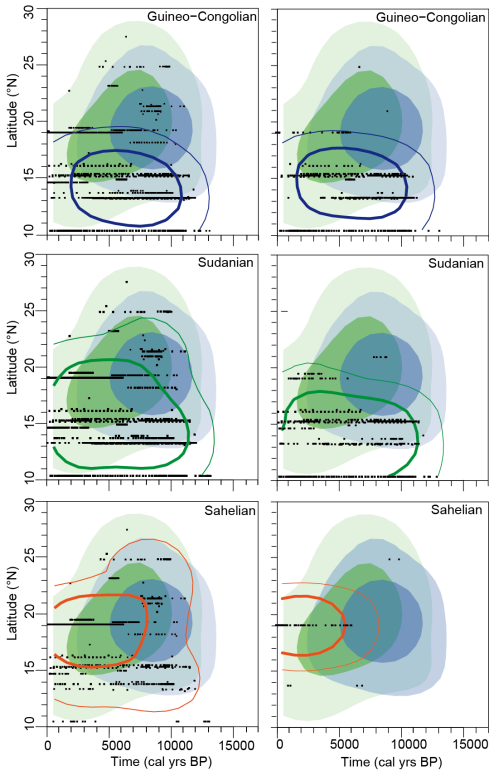

Fig. 2. Spatio-temporal changes (in latitude and millennia) in pollen taxa presences within the Guineo-Congolian, Sudanian, and Sahelian groups during the Holocene using probability density functions

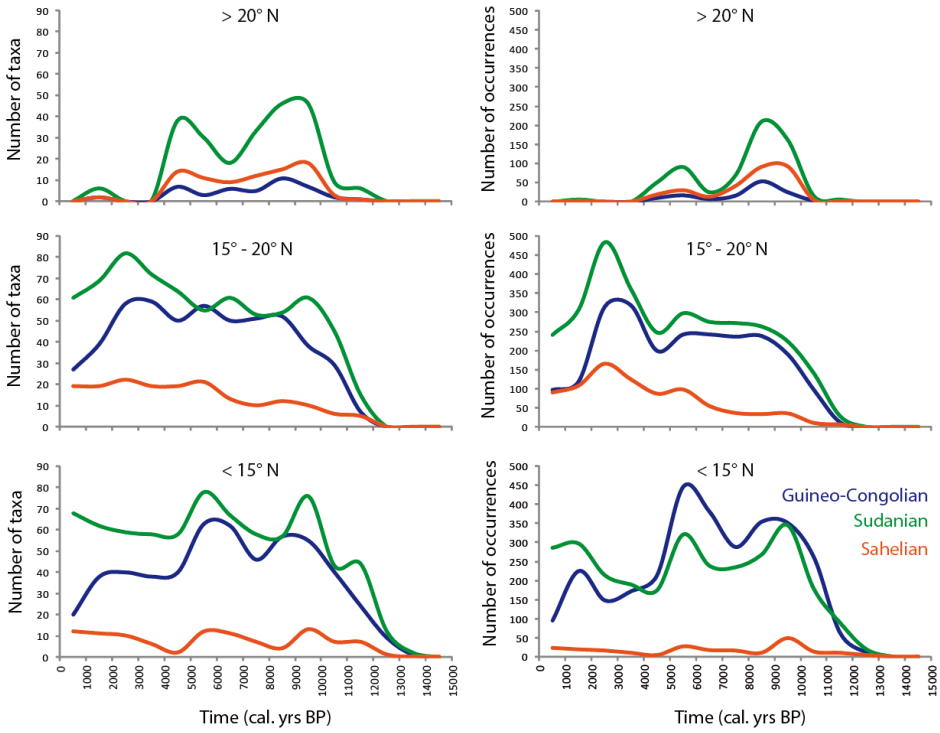

Fig. 3. Change in biodiversity within the Guineo-Congolian, Sudanian, and Sahelian groups (including exclusive and non-exclusive taxa) as a function of time in the three latitudinal zones

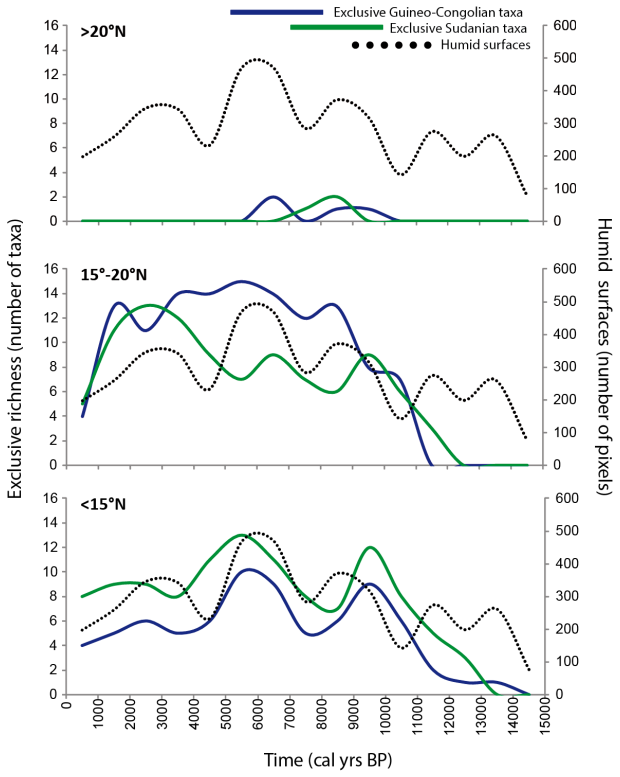

Fig. 4. Variation in the number of exclusive Guineo-Congolian and Sudanian pollen taxa compared to paleohydrological changes during the Holocene for the entire studied area