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Climate of the Past Discussions

Interactive comment on "Palynological evidence for gradual vegetation and climate changes during the "African Humid Period" termination at 13° N from a Mega-Lake Chad sedimentary sequence" *by* P. G. C. Amaral et al.

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RESPONSE TO THE INTERACTIVE COMMENT OF U. SALZMANN

First of all, we would like to thank Dr Ulrich Salzmann for his comprehensive comments and questions that will allow us to significantly improve our final manuscript.

GENERAL COMMENTS

The main concern of the reviewer is related to the quantitative estimates of mean annual precipitation (Pann), especially because of the large error bars reported in our

Pann reconstruction. We agree with the reviewer that rainfall estimates from pollen fossil data in semi-arid regions remains challenging. In northwestern Africa, attempts of quantitative estimates of Holocene climate remain scarce until today. As mentioned by the referee, our paper is clearly original on this point, but as also pointed out, we recognize that it may require more in depth discussion about the limits of our reconstructions. In the revised paper, we will discuss thoroughly the two major points raised by the referee: (1) how and why these climate reconstructions can fail, particularly concerning the large uncertainties, and (2) the occurrence of extrazonal vegetation around the paleolake Chad, which would hampered our estimating rainfall from fossil data. However, we underscore that, even if the confidence intervals are large (partly because of a lack of good modern analogues), the trends remain significant. We detail our arguments in the next sections.

1. The large error bars in Pann reconstructions

Even if a clear trend toward drier conditions is observed in our reconstructions between ca. 6700 and ca. 5000 cal yr BP, with Pann estimated values of ca. 800 mm and of ca. 600 mm before and after ca. 6050 cal yr BP respectively, our quantitative estimations show large error bars. It is important to note that, these large uncertainties are close to those computed in previous works performed in central (Lebamba et al., 2012) and central east Africa (Bonnefille and Chalié, 2000). At least three hypotheses can be proposed to explain such uncertainties in our Pann reconstructions: (a) the Mid-Holocene vegetation in Lake Chad Basin (LCB) would have no best analogue in modern west and central African vegetation or, if such analogues have occurred, they have been largely modified by recent human impact; (b) the representativeness modern pollen database of some types of vegetation which would seem to have empirically the best affinities with the mid-Holocene vegetation reconstructed in paleolake Chad vicinity may be questioned. In this database, modern pollen assemblages from central African dry and humid Sudanian woodlands are under-represented while modern pollen samples from north-central Guineo-Congolian mosaic of rain forest and secondary grassland are nearly missing (see Fig. 7); and/or (c) the composition of the modern pollen database used for our reconstructions could be considered not well adapted. Indeed, it mainly includes pollen assemblages from surface soils representing the modern pollen rain from a reduced area, while pollen assemblages from lacustrine sediments are more representative of pollen rain from a large panel of vegetations (local, extra-local and regional), particularly in great lakes with a large catchment as the LCB. In this case, the representativeness of the modern pollen database for quantitative reconstruction in large scale basin is questionable and it seems plausible that no best or very close modern analogue can be found in this database. At this stage, it is impossible to point only one hypothesis among the three proposed above. It is more probable that all of them have somehow biased our Pann reconstructions and hence are responsible to the large error bars. As the closest analogues are usually acceptable and the following ones are taken by default, this enlarges the error bars but not really the median reconstruction.

2. Selection of taxa for Pann estimates and their influence on the quantitative reconstructions: the presence of “extrazonal vegetation”

The referee has raised the hypothesis that our rainfall estimates from LT1 pollen sequence of Lake Chad could be “strongly hampered by occurrence of extrazonal vegetation (i.e. vegetation that occurs outside of its main distribution area by occupying habitats with favorable environmental conditions)”. This point concerns our vegetation reconstructions, which consider the occurrence of southern humid trees, such as Uapaca, in the present dry Sahel region more as a zonal than an extrazonal occurrence, and so it is in disagreement with previous reconstructions proposed at Lake Tilla (Salzmann et al., 2002) and in Manga Grassfields (Salzmann and Waller, 1998; and Waller et al., 2007). In these works, the humid elements found today far southward, as Uapaca, have been “unambiguously” identified as swamp forest elements related to local favorable topographical and hydrological conditions during the Holocene, i.e. as a extrazonal occurrence of these elements in modern dry Sudanian and Sahel areas.

According this, it might be supposed that similar swamp forest formations, including particularly Uapaca trees, would have occurred as extrazonal vegetation on the shorelines of paleolake Chad between ca. 6700 and ca. 5000 cal yr BP. This implies that these humid elements were not in equilibrium with regional climate and they should not be used for estimating regional rainfall, i.e. they must be excluded from our fossil dataset before performing our quantitative approaches.

2.1. Occurrence of extrazonal swamp forest on the shoreline of paleolake Chad

We do not think that Holocene extrazonal forested vegetation, as reconstructed around Lake Tilla or in the Manga depressions, might occur or were largely developed on the shorelines of paleolake Chad. On the basis of our pollen data, we believe that such extrazonal formations would have preferentially established and maintained locally around small lakes or in dune depressions, mainly fed by groundwater input leading to a relatively stable surface elevation of water level, and so allowing favorable local conditions to support a permanent swamp forested environment during humid periods such as the AHP. However, at Lake Chad, the local conditions must be quite different. The Lake Chad occurs in a flat regional topography area and it is very sensitive to local and regional climate variations, implying large fluctuations of the lake surface and in the position of the shorelines as observed during the last decades by Olivry et al. (1996), and it must be also the case of the paleolake variations during the Holocene. Thus, the presence of permanent swamp forest around the lake during at least 1700 years is questionable. Such instability of paleolake Chad surface can be testified in the time interval record in core LT1 by centennial fluctuations in Cyperaceae frequencies, representing phases of extension or reduction of swamp/marshy environments due to short time variations in lake level. Their lowest frequencies registered between ca. 6500 and ca. 6300 cal yr BP can be interpreted as corresponding to a maximum surface area of the paleolake during the whole period encompassed by LT1 core (see also reply to D. Verschuren’s comments), i.e. to a high lake stand. This scenario is in agreement with the maxima of Pann estimated values and would imply that the shorelines were, at this time, at its maximum distance to the LT1 core location. Thus, if Uapaca testified the occurrence of extrazonal swamp formations established around the paleolake, it would be expected a similar and contemporaneous decrease in Uapaca and Cyperaceae frequencies. Nevertheless, an inverse trend in the frequencies of these two taxa is observed in our pollen sequence. This feature would indicate that Uapaca could not have occurred on the shorelines of palaeolake Chad in swamp formations as an extrazonal edaphic element, but preferentially in the vicinity of the palaeolake as part of a zonal wooded savanna or woodland with Sudanian affinities as proposed in our manuscript. According to our hypothesis, the selection of these taxa in our dataset cannot hamper our Pann reconstructions. Another argument in favor of a zonal occurrence of Uapaca can be the fact that in our Pann reconstructions, among the five best analogues, any swamp forest samples were selected, e.g. swamp forest from Cameroon (Vincens, unpublished) or from Gabon (Lebamba et al., 2009b), even if this samples exhibit similar frequencies of Uapaca to those found in LT1 core. This attests that the selection of the best analogues was not primarily influenced by the high frequencies of Uapaca pollen, but by the whole microfloristic composition of the modern pollen assemblages.

2.2. Selection of pollen taxa in biomization and Pann quantitative estimates in the LT1 pollen sequence: the “non-edaphic” taxa

We have considered as non-edaphic pollen taxa: (i) those originated from plants clearly growing on well-drained soils, and (ii) those which, in the lack of precise identification (at a generic or a specific level), no differentiation can be made between terrestrial and edaphic plants from which they come from. This is the case of many taxa identified in LT1 pollen sequence from Lake Chad, such as Uapaca, with certain species occurring in swamp (ex. U. guineensis) or riverine forest (ex. U. heudelotii) but also in woodland (ex. U. togoensis), Alchornea or Syzygium that can occur in a great range of vegetation types, as well as the Combretaceae undiff., Euphorbiaceae undiff., Rubiaceae undiff. . .. If we must remove all pollen taxa that possibly could have been originated from edaphic plants, we must have to remove also the Poaceae, with their numerous edaphic species

(swamp, saline soils. . .), Acacia for its species along rivers and many others. Thus, all these pollen taxa have been considered in our reconstructions, as it is done in all quantitative reconstructions of climate. In conclusion, it appears clear that the presence of humid tree elements during the Holocene in currently semi-arid regions (northern Sudanian and Sahel regions), and its interpretation in terms of distribution, zonal or extrazonal populations, is subject of debate. But, we think that this debate will be definitely ended only when real specific identification of the pollen from these plants, and particularly here of Uapaca, will be possible on each Holocene site. Moreover, we think that fossil pollen assemblages must not be similarly interpreted in small humid depressions or small lakes and in large lakes, as is the case of Lake Chad.

SPECIFIC COMMENTS

Abstract: Attending to the referee’s comment, the abstract will be shortened in the final version of the manuscript.

Introduction

- 2323/13: “ca. 6000-5500 yrs ago” will be deleted in agreement with the reviewer, according that the age of the AHP termination is still a subject of debate in West and central Africa.

-2323/22: the two references “Hoelzmann et al., 1998” and “Lézine et al., 2011” will be include in the final manuscript.

- 2324/8: reword “local recycling of precipitation” replace by "local moisture recycling"

- 2326/2: The reference of Jikariya Lake record (Waller et al., 2007) will be incorporated in the text (introduction and discussion). However, the pollen data of this work is not available in the African Pollen Database such as all other pollen sequences from the Manga Grassfields, therefore, the Holocene variation in Uapaca frequencies from this record will be not included in Figure 10. Moreover, the reference of Street-Perrott et al. (2000) will not be integrated because this work do not concern new pollen results.

- 2326/10: We will reword the end of the introduction which was ambiguous (a comment also pointed by D. Verschuren referee). What we want to underscore is that our LT1 pollen sequence encompasses part of the mid-Holocene transition (and not the whole mid-Holocene transition as written), but was continuous between ca. 6700 and 5000 cal yr BP. The upper part of the pollen sequence presented in this paper was very likely truncated by wind deflation during later drying phases of Lake Chad.

Material and methods

- 2328/19: A new version of the Figure 3 will be drawn to better distinguish changes in lithological profile. Indeed, in this picture of the core it was difficult to see the fine laminations in some parts of the core. The legend of sedimentology will be included.

- 2330/17 and 2331/8: the problem of identification of "non-edaphic pollen taxa" is detailed above. Our selection of pollen taxa will be more detailed in the final manuscript.

Results

- 2332/27: The full pollen record will be provided as supplementary material.

- 2333/4: The coordinates (latitude and longitude) of each site will be included in the Table 2. We opted to not put this information directly in the Fig. 5 to avoid to make the figure heavier.

Interpretation and discussion

- 2340/4-8: The sentence will be rewritten according the reviewer comment.

- 2341/19: In the same way, we will delete the sentence "Guineo-Congolian lowland rain forest" at Lake Tilla, a re-interpretation which is not supported by Salzmann et al. (2002).

- 2343/16: "extra-regional" will be replaced by "long distance transport" and the reference of Waller et al. (2007) will be included in the final manuscript.

TECHNICAL CORRECTIONS

All these corrections will be made in the revised manuscript.

REFERENCES

Bonnefille, R., Chalié, F.: Pollen-inferred precipitation time-series from equatorial mountains, Africa, the last 40 kyr BP, Global and Planetary Change, 26, 25-50, 2000.

Hoelzmann, P., Jolly, D., Harrison, S.P., Laarif, F., Bonnefille, R., Pachur, H.-J. and TEMPO: Mid-Holocene land-surface conditions in northern Africa and Arabian Peninsula: A data set for the analysis of biogeophysical feedbacks in the climate system, Global Biochem. Cycles, 12(1), 35-51, 1998.

Lebamba, J., Vincens, A., Jolly, D., Ngomanda, A., Schevin, P., Maley, J., Bentaleb, I. and REGAB Members: Modern pollen rain in forest ecosystems of Gabon and Cameroon, Central Atlantic Africa, Rev. Palaeobot. Palyno, 153, 34-45, 2009b.

Lebamba, J., Vincens, A. and Maley, J.: Pollen, vegetation change and climate at Lake Barombi Mbo (Cameroon) during the last ca. 33,000 cal yr BP: a numerical approach, Clim. Past, 8, 59-78 2012.

Lézine, A.-M., Hély, C., Grenier, C., Braconnot, P. and Krinner, G.: Sahara and Sahel vulnerability to climate changes, lessons from Holocene hydrological data. Quaternary Sci. Rev., 30, 3001-3012, 2011.

Olivry, J-C., Chouret, A., Vuilaume, G., Lemoale, J. and Bricquet, J-P.: Hydrologie du lac Tchad, ORSTOM, Paris, 1996.

Salzmann, U., Waller, M.: The Holocene vegetational history of the Nigerian Sahel based on multiple pollen profiles, Rev. Palaeobot. Palyno., 100, 39–72, 1998.

Salzmann, U., Hoelzmann, P. and Morczinek, I.: Late Quaternary climate and vegetation of the Sudanian zone of northeastern Nigeria, Quaternary Res., 58, 73-83, 2002.

Waller, M.P., Street-Perrott, F.A. and Wang, H.: Holocene vegetation history of the Sahel: pollen, sedimentology and geochemical data from Jikariya Lake, north-eastern Nigeria, J. Biogeogr., 34(9), 1575-1590, 2007.

Interactive comment on Clim. Past Discuss., 8, 2321, 2012.