

Firstly we wish to thank Françoise Chalie for the thorough review of our submitted article and for the positive comments provided and the recommendation that '*this important article* [subject to revision] *be accepted for publication*'. We have, in nearly all instances considered and addressed the changes suggested by the reviewer; many of these were extremely helpful in content and have certainly improved aspects of the paper. We address the each revision, in turn, below.

## **SPECIFIC COMMENTS**

**Abstract** – The abstract has now been amended to suit the revisions of the text, figures and statistical analyses. The lake level responses of both lakes (Nyamogusingiri and Kyasanduka) to the LIA are now outlined.

**1. Introduction** P.5186 l.18-20 – we have now altered this part of the introduction (and other parts of the text) to clarify and remove any ambiguity from this statement – this also addresses (in part) a comment made by Reviewer 2. A lake with a high CA:L is sensitive to P:E over its catchment, essentially amplifying the effective precipitation signal over the groundwater signal. In this study, Lake Kyasanduka appears less sensitive to changes in lake level / conductivity as, despite lower CA:L, it must receive a high input of freshwater groundwater (buffers the response). It is likely that the groundwater influence at Lake Nyamogusingiri is less, and as a result the deeper basin becomes non-linearly sensitive when it is isolated from the larger basin. It is likely that the deep basin of Lake Nyamogusingiri, with a low CA:L becomes sensitive to E when P is so low that the system is isolated; whereas the lake is more sensitive to P when there is a large CA:L (as E only affects lake surface). We are, therefore, suggesting that the lakes reflect (amplify) P over E as their CA:L increases (and amplifies E over P [and vice versa]), and only groundwater can change this which it likely does at Kyasanduka, which may explain why this lake did not dry out or go salty during the LIA and other documented drought events.

P.5186 l.19 - we have added in the word 'area'.

**2. Study sites** P.5187 l.7 – We agree that Lock (1967) is an old reference. Unfortunately the study sites lack any modern monitoring data, and the majority of data that can be found (even short-term monitoring) dates back to the sixties, especially in this remote part of western Uganda. This is in part due to the dissolution of the Protectorate, after which monitoring/meteorological stations were abandoned. The range is large as it encompasses partly the rift valley floor (which is in the rain shadow of the Rwenzori Mountains and the rift valley shoulder, which tends to be wetter). Modern data are available from Kampala and Entebbe, but given the altitude and location of these sites are not true reflections of the precipitation in the west. The data we present is the most 'recent' we can find that is accessible. Sentences have now been added to cover precipitation seasonality/inter-annual variability and the link to ENSO.

P.5187 l.2 – unfortunately we do not have an absolute value for 'long-term' in this context, but the lower lake levels must have persisted long enough for the trees to establish to such a size that they could potentially withstand inundation events, or to have fully matured before the lake level rose (possibly killing the trees?). A sentence has been added to clarify this.

**3. Materials and methods** P.5188 l.3-6 – this has been clarified, as the deep crater of Lake Nyamogusingiri was cored (which was the centre) and the centre of the broad, flat Lake Kyasanduka was cored. The depths (as per the study site description immediately above) have been added here, as has a reference to Figure 1 (coring locations).

P.5190 l.22-24 – in the earlier part of the methods we have now clarified that the 133 and 278 samples counted included overlapping samples to ensure that the cores were correctly correlated (further clarification is included in the Supplementary Information to which the reader is directed). This also addresses a comment by Reviewer 2. We have also re-analysed all of the data presented and decided this would be better justified if the ‘zones’ chosen were identical to the diatom zones. This is a significant change to the paper in terms of the RDA analyses. A new explanation as to how this was done has been inserted into Section 3.3.2. It involved some slight modification of the datasets, but again this has now been stated in the paper and we hope this change has made the paper and the analyses more justifiable and easier for the reader to follow. Again, this should help address a comment raised by Reviewer 2.

**4. Results** P.5191 l.21-23 – the wording has now been modified to make it more obvious that an explanation for each C-14 rejection is given in this Supplementary Information.

P.5192 l.5 – The zones were determined using the method of Birks & Gordon (1985) in the program ZONE – this is stated in the methods section (under sub-heading 3.3 Numerical methods). The statistical validity of these zones was tested using a broken stick model. The zonation on the diagram was detailed because of the above method, but as the focus of this paper was not the diatom stratigraphy *per se*, we had summarised the diatom information to avoid making this paper too long. We have now changed the zones on the diagram to reflect the new data summary and added in zone names. Consistency between the text and figures has now also been checked and changes made where necessary.

P.5192 l.5 – this change has been made.

P.5192 l.15 – we have now checked for consistency. When a diatom is first mentioned its name is given in full, after which it is referred to as its abbreviated form. Only when a species name starts a sentence is the genus given in full again.

P.5192 l.15 & l.18 – it is suggested that if *N. lancettula* represents higher lake levels compared to known lake level changes and the link to sunspot cycle), that stratification of the water column is likely to be much stronger as the water column would stabilise and not be as susceptible to wind mixing; hence how the species could be used to infer both scenarios.

P.5192 l.21 – see comment above (P.5192 l.15). We are suggesting a potential scenario based on the information we have available on the species *N. lancettula*.

P.5194 l.19-21 – this is a fair point (see response to comment P.5195 l.2-3, below). However, given a lack of modern data for many of these species, we do need to make the best of the literature available to us with regards to the modern distribution. We do warn about using absolute values for water chemistry when interpreting changes in lake sedimentary sequences using transfer

functions (Mills & Ryves, 2012), as it is important that we do not dismiss observed ecologies at the expense of a model. We have endeavoured to make our sources / references clear, and these, unfortunately, are not exhaustive, and with some of these species very little information exists in modern Africa and the species do not appear in current calibration / training sets. We are putting forward potential scenarios and invite the reader to form their own opinions based on the information, interpretation and discussion that we provide.

*P.5193 I.1* – a zoom-focus of Figure 4a (now Fig 4b) showing the last 100 years for Lake Nyamogusingiri has been added to the paper.

*P.5193 I.20* – this has now been corrected. It was an issue with the age model and had not been updated correctly with the new age models developed for this paper using CLAM.

*P.5194 I.19-21* – We think this suggestion is too much speculation. It is more likely (and simply) that there is more P coming into lake and *Aulacoseira* is outcompeted, as the abundance of benthic/aerophilous taxa imply catchment input. Diatom concentrations suggest that the productivity is high so perhaps supports the hypothesis of higher P. It may not be a turbidity signal, rather diatom/algal shading as the lake gets more productive.

*P.5195 I.2-3* – this is a fair point raised by the reviewer with regards to *N. palea*. For this research, and due to a wider collaboration / exploration of the diatom data with regards to the development of the transfer function, all taxonomy was checked by an East African diatom taxonomist, so we are confident assigning *N. palea* to the diatom observed in these samples. We accept there are many cryptic species, but these could not be resolved using a light microscope. As the '*N. palea*' (as assigned) occurred in clustered samples we assume they reside in a similar habitat preference. We accept there is always uncertainty when understanding the environmental preference of any diatom species, and we do not provide an exhaustive review of the literature with regards to this taxon and have endeavoured to be clear as to the references used. We have given our interpretation, and this is certainly not univocal, but again the reader is invited to form their own opinions based on the evidence and the interpretation / discussion we provide. To ensure the reader can explore this further, we have added in the important references suggested by the reviewer.

## **5. Discussion**

*P.5191 I.8* – title of sub-section 5.1 changed as per reviewer suggestion.

*P.5195 I.15* – lake level reconstructions are based on the relative abundance of the planktonic flora in both sequences this is due to the high abundance of facultatively planktonic species (specifically *Cyclotella meneghiniana*) which we feel, in these systems, represents a response to nutrient input rather than lake level. So in this instance the ratio was not used to avoid potential complication.

*P.5196 I.1* – as noted by the reviewer we have added in the Gasse et al. (1995) reference. We have not included the optimum, just the range of published values for the taxon.

*P.5196 l.1-4* – Kilham (1971) suggests a low conductivity optimum also – we have included this reference to support our statement. We have already acknowledged the broad, and much higher salinity range in the EDDI East African database and readers are referred to Mills & Ryves (2012) for a further discussion, we have now made reference to the higher conductivity issue, however we do not expand too much in detail here as it is not relevant to the wider scope of the paper.

*P.5197 l.11-12* – erroneous sentence, the periods for the statistical analyses do not overlap as per the methodology stated.

*P.5198 l.8 & P.5198 l.11* – consistency issue, the text has now been updated to ensure that figures and text match.

*P.5198 l.11-13* - these factors have been taken into account and the statement has been corrected / expanded in the text.

*P.5199 l.2* – this appears to be a qualifying comment from the reviewer and needs no change.

*P.5199 l.11* – the chronozones common to both cores were based on visual agreement (now stated in the text). The statistical zones are noted on the [old] figure 5 (vertical lines above the respective lake level curves), attention has now been drawn to them in the figure caption, and they have been updated to reflect the detail of zones on Figures 4a and 4c / Results. We do not suggest that a synchronous chronozone infers an identical change, just that a response is seen in both lakes at a similar time (perhaps caused by the same driver?) – this response could be anti-phase, but the important point is that the change starts at the similar time.

*P.5200 l.3, P.5200 l.7 & P.5200 l.20-21* - consistency issue, the text has now been updated to ensure that figures and text match.

*P.5200 l.23* – we have indicated that the Verschuren (2004) reference is a review and we have now cited Maley (2010). Unfortunately we were unable to access the earlier papers, and we prefer to cite what we have read.

*P.5200 l.27, P.5201 l.15-17, P.5210 l.18, P.5202 l.1, P.5202 l.13-14, P.5202 l. 16-17 & P.5203 l. 14-15* - consistency issue, the text has now been updated to ensure that figures and text match.

*P.5203 l.25* – an alternative explanation for this potential anti-phase has now been included in the text, and it likely a result of a problematic interpretation of the diatom record from the shallow lake system. We have noted in the text that the record from L. Kyasanduka may be ambiguous. The sequence during the LIA is dominated by *Aulacoseira* species, often associated with ‘deep’ water, but as L. Kyasanduka can not reach depths much greater than c. 3 m, it may be that the diatoms are responding to light/turbidity driven changes in a much shallower system as well as changes in the Si: P (cf. Kilham & Kilham, 1990).

**6. Conclusion** – We fully agree with the reviewer that a comprehensive understanding of the present day system is important to understanding an ecosystem’s response to climate and human disturbance, and we have added in a sentence to reflect this and the need for a multi-lake study (i.e. more than 2 lakes) across both a modern climate gradient and human disturbance gradient

(this also addresses a comment made by Reviewer 2). The alternative approach is that of a transfer function (e.g. Mills & Ryves, 2012) which is not without its issues when applying a modern calibration dataset - with clear human impact issues to systems that have not experienced such changes in the past.

## FIGURES AND TABLES

*Fig. 1: 'Show total catchment area for Lake Nyamogusingiri'.* Unfortunately we are unable to do this as we do not have an electronic nor hard copy version of the map that covers the area to the west of Nyamogusingiri. The catchment was calculated using the data we had available at the time.

*Fig.1: 'Cross should appear in legend / be more legible'.* We have amended this figure, changing the cross to a red dot, and adding to the legend.

*Fig.2b/3b: 'Explicit in legend meaning of black line'.* This is the total Pb-210 inventory and a legend has been added to both figures. The caption has also been updated on both figures to note that the Pb-210 concentrations are on a logarithmic scale. Fig.2e/3e now include a legend detailing the colours on the age model and the caption of Figure 3 now explains the significance of the grey band.

*Fig.4: 'Diatom data are only briefly presented; split into 4 figures'.* This was purposefully done for this paper. This is not because we do not value the data, rather we were not certain that a detailed diatom analysis was suitable for the general climate audience of *Climate of the Past*. We have split the diagram into 4 figures. It seems the reproduction of the figures in the online pdf version is very small, and it is hoped that final production of these figures may be in landscape orientation, rather portrait? We thank the reviewer for her kind words with regards to the value of this data in terms of being a reference dataset for this region and as such we would like to point out that the data will be made open access via NOAA-NCDC and the record logged with PAGES Africa-2K so that the information may be used by other diatomists / researchers in the field. The original statement pertaining to this was removed from the acknowledgements as we had not lodged the data prior to submission of this draft manuscript. However, the link will be included in the final version should this paper be accepted for publication.

*Fig. 4:* has now been split into 2 figures. The new Figure 4 shows more detailed/enlarged diatom data from Lakes (a,b) Nyamogusingiri and (c) Kyasanduka and Figure 5 shows the summary data from the two lakes [(a) Nyamogusingiri and (b) Kyasanduka; note that 'Inorganic flux' on both diagrams has been replaced by 'Minerogenic flux' so it matches with the main text. We have also updated the figure captions to reflect suggestions by the reviewer (e.g. diatom concentration units [as there is not room on the figure itself], adding in 'optimum'). The F index and zoning has also been clarified in the figure captions and have also been inserted into the text (see also Methods).

The jack-knifed error has now been included on the new Figure 5, and the RMSEP log value is now included in the caption.

*Fig. 5. 'Almost the same comment as Fig. 4, difficult to read'. This has now been updated to Fig. 6. This figure appears to have suffered the same reproduction issue as Figure 4, and has appeared as a very small figure when downloaded online, this may be partly rectified in the final reproduction of this paper, but changes have been made by the authors to improve clarity.*

*Timescale should cover period AD 1000-2000 – the time scale has been modified to AD 1050-AD 2007 to encompass the full record of Lake Kyasanduka.*

*Explicit in the legend the red curve, marks above curves and grey bands – an explanation has now been added to the figure caption.*

*Is there a logic sorting of curves? – No particular logic was applied to the ordering of the curves and we have reordered as per the reviewer's suggestion.*

*Sunspot curve – the error in this curve has now been corrected and units added.*

*References for curves – we have now included the references in the figure caption (as well as the Supplementary table). The supplementary table remains (and has been updated to include the Lake Edward reference) as this is still relevant to the main text.*

*Table 3 – missing period ('X') completed.*

## **TECHNICAL CORRECTIONS**

*P.5184 l.18-24 – this section already comprises of multiple sentences, unsure of Reviewer's suggestion(?), change has not been made.*

*P.5187 l.14 – change made.*

*P.5192 l.8 – change made.*

*P. 5192 l.26 – change made.*

*P.5203 l.7 – change made.*

*P.5193 l.1 – a zoom-focus of Fig 4a (last 100 years) has now been added (Fig. 4b).*

*P.5194 l.27 – change made.*

*P.5195 l.16 – change made to 'from'.*

*P.5197 l.13 – change made.*

*P.5198 l.10 – the lake, locally, is spelt 'Kitigata' – in more recently published papers it appears as Kitagata. Spelling currently remains unchanged.*

*P.5201 l.20 – change made.*

*P.5205 l.1 – remains unchanged as work (not works).*

P.5205 l.9 – all instances corrected to ‘over-ride(s)’

## **BIBLIO. REFERENCES**

P.5206 l.20 – change made.

P.5206 l.21 – ‘Change *Palaeogeogr. Palaeocl. to Palaeogeogr. Palaeoclimatol. Palaeoecol.*’ In the original submission, all references to this journal were as the reviewer suggested (*Palaeogeogr. Palaeoclimatol. Palaeoecol.*). The change was made during the typesetting phase. We have corrected to the original submission, but this may well be corrected by the journal once again.

P.5208 l.24 – change made.

P.5210 l.4 – change made.

P.5210 l.7 (21?) – change made.

P.52121 l.15 – change made.

## **SUPPLEMENTARY INFORMATION**

*Rename Figures* - the figures within the text have now been referred to as Figure S1, S2 etc. Changes have also been made to the main body of text. CoP did not give a convention for supplementary information, so we thank the reviewer for helping us to clarify this.

*Homogenise name of cores* – this has now been corrected throughout the manuscript and ‘K’ (Kyasanduka) has now been added before each of the core codes to avoid any ambiguity between the two lakes.

*First paragraph is 1. Results, but no paragraph 2* – as is the suggested convention of the main body of text, the various levels of sub-headings (1, 1.1, 1.1.1) are used in the supplementary text as in the main body. We have not changed this convention and await advice from the *Editorial team* or *CoP* before changing.

P.1 l.15-17 – we do not suggest that the occurrence of *Thalassiosira rudolfi* is shown in the supplementary figure (the statement appears after reference to the supplementary figure), however, we have changed the text to refer the reader to Fig. 4a where the reader will be able to see the presence of *T. rudolfi* in a restricted section of the core sequence.

P.2 l.6-7 – we are not sure we understand the reviewer’s comment. We accept that even if radiocarbon ages are not in sequence, this does not necessarily mean that the calibrated ages would fall out of sequence. However, the 2 ages for the basal sediments of Lake Nyamogusingiri, either as a raw radiocarbon ages or as calibrated ages are several hundred years younger than all of the dates above. The issue raised by the reviewer does hold true for the first radiocarbon age in the sequence (SUERC-18911) as this particular radiocarbon age, when calibrated, coincides with a

plateau in the calibration curve, giving a much wider span of ages/probability. The program we used to create the age models is robust, with multiple iterations. All ages were included in the modelling and only rejected when a model could not be fitted to all dates. The purpose of the age modelling using CLAM for R with a smooth spline was to ensure as many ages as possible could be included in the models. These dates remain 'rejected' and are explained in the text.

*P.2 l.17 – 'Clarify versus which reference (0 cm) are the core depths calculated'* – the 'numbers' in the text refer to the length of each core, not the correlated depth. Assuming the top of each individual Russian core chamber is 0 cm and the base is 100 cm, each individual sediment core is measured as a length of this chamber. We indicate on Fig S2 where sediment is missing/not collected. We have added in a sentence to clarify this in the text, but this sentence may be more confusing than helpful?

*P.4 l.14 – 'Supplementary Table 2 became Table 1 of main article'* – indeed this is true, this is an error on our part and has been corrected.

*P.5 l.21 – 'Laminations restricted to only few-cm bands'* – the original statement pertaining to this has been removed.

*P.5 l.25-27* – change made.

*P.5 l.32 + P.6 l.1* – change made.

*P.5 l.32 + P.6 l.1 – 'Discuss rejection of two basal dates from lake Nyamogusingiri here'* – as with the format of this Supplementary Information, a short discussion with regards to the rejected date occur in the section on Lake *Nyamogusingiri* (just as rejected dates from Kyasanduka are discussed in relation to that specific lake). The reasoning is given on P.2 l.9-15. As outlined in a response above, neither of these dates (calibrated or un-calibrated) not give ages in sequence (Table 1 and Figure 2).

*Fig. S1 + S2* – we have altered the size of the text relating to the radiocarbon samples (these are not ages, just the sample codes that correspond to the table in the main text). We have not changed the size of the data points, even where data are overlapping. If the symbols are made smaller, the colours are difficult to decipher.

*Fig. S2* – corrected spelling of 'susceptibility' on axis title.

*Fig. S3* – The lack of red boundaries are an oversight on our part. This has been amended.

*References* – again, no convention was given for references that appear in the supplementary information, so for completeness, all references that appear in the supplementary information are given in full at the end of the document. This means we have now included the Stuiver & Reimer (1993) reference.