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Interactive comment on "Seasonal deposition processes and chronology of a varved Holocene lake sediment record from Lake Chatyr Kol (Kyrgyz Republic)" *by* Julia Kalanke et al.

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Referee comment: Although I have no major comment on the central topic of this paper (that is suitable for the journal), i.e. the chronology, I am puzzled why there is no μ-XRF data (e.g. Itrax) shown in your study. For example, the authors describe periods of prevailing anoxic bottom water conditions, calcitic materials/diatoms, coarse vs finer sediments, etc. In my opinion, it would be very helpful to show μ-XRF elements (and elemental ratios) to support your visual microscopic analysis. Have you made such analysis (XRF)? If you are to interpret the paleoenvironments from this site in the paper, I think that would be very valuable.

Author′s response: We appreciate the constructive comments and suggestions of referee #2 and we now included XRF mapping to strengthen detailed microfacies analysis presented in our MS. The main focus of the MS is a detailed microfacies analysis for 1) the development of process-based deposition models and 2) the establishment of detailed varve-based chronology. For these purposes, detailed microfacies analyses is crucial and allows to distinguish, for example, detrital from endogenic calcite and detrital quartz from diatom SiO2. Such differentiations are not possible using μ-XRF scanning as element abundances, as these sediment fractions are geochemically identical and it is not apparent from, for example, relative variations of calcium and silicon respectively. However, we do agree that XRF element scanning is a powerful way to complement and support visual microfacies observations. Therefore, XRF scanning maps of sediment blocks are used, which are the equivalent of the thin sections used for the microfacies analyses. These new mapping results for selected intervals with characteristic varve types confirm the occurrence of both detrital and endogenic calcite. These data are presented in a new Figure 4.2 and in the main text (new chapters 3.3 and 4.4 μXRF element mapping, discussion within chapters 5.4.2 and 5.4.3) of the manuscript. To our opinion, XRF mapping results are most suitable for a precise linking of sediment compositions and microscopic observations. We add Rik Tjallingii as a co-author because he conducted the μXRF element mapping and helped with revising the manuscript.

Moderate comments:

Referee comment:

1.There is an excellent matching between the varve counts with the 2 dated wood samples. However, there is almost 6000 years (firstâĹij360 cm) without chronological constraint. Given that many varves are qualified as 'unclear' from 130 cm toâĹij270 cm of the composite depth, perhaps some other dating techniques could be added such as paleomag, OSL, 14C, etc. I would encourage the authors to at least comment on this.

Author′s response: The reviewer is right that the age uncertainties are higher in this interval of less well preserved varves which we have addressed by allocating higher uncertainty ranges. Nevertheless, varves in this interval can still be counted and represent the only applicable dating method. We have sieved the entire interval in order to find terrestrial plant remains for radiocarbon dating but, unfortunately, without any success. All five 14C dates obtained from this interval are from aquatic material and thus revealed too old ages due to reservoir effects. Independently paleosecular variation (PSV) records in this region are only available from Lake Issyk Kol, Lake Baikal and Lake Aslikul. However, these records suffer from dating problems and show significant temporal offsets before 500 AD between the records and to global geomagnetic field models (GómezâĂŘPaccard, 2012) so that they cannot be used for the Chatyr Kol chronology. OSL dating is also not applicable because the Chatyr Kol sediments are mainly composed of materials not suitable for reliable luminescence dating including carbonates, organics and non-aeolian siliciclastic.

Author′s change in manuscript: We have changed 'unclear' to 'less well preserved' varves (chapter 3.2).

Referee comment: 2. Have you used any particular software to count the varves, please provide what you used.

Author′s response: No software was used for varve counting. Counting was exclusively performed on the Axioplan microscope using different magnifications and based on expert knowledge.

Author′s change in manuscript: none

Referee comment: 3. The names of the cores and their depth are indicated in Fig.3. However, it is unclear in my opinion which cores were used for the composite. I assume A1o, and some part of the A3o, A3u...In brief how much sediment was used from each core sections?

Author′s response: The core sections used for the composite profile are colored in grey, as indicated by the legend.

Author′s change in manuscript: We add the depth sections of each core used for the composite profile in fig. 3.

Referee comment: 4. Fig. 1: Have you obtained several (7) gravity cores that are not in the same location of the composite core?

Author′s response: As indicated in Figure 1, the gravity cores 3, 5, 6 and 7 were obtained close to the composite core location while gravity cores 1 and 2 were recovered about 1-1.5 km further north-east and number 4 was recovered $\sim$ 10 km further east in the shallow eastern lake basin.

Author′s change in manuscript: none

Referee comment: 5. Solar activity: Lines 414-416: Raspopov et al., (2008) use a 100-300 year band-pass filter and find 'great correlation' with solar activity (inferred from 14C) from three locations or so, and with lags (as high as 150 years). One can do the same analysis with white noise and find similar correlation (for example see Turner et al. 2016: Solar cycles or random processes?). But more importantly, they filter out (bandpass) the data which make any high correlation not surprising at all. The comparison of the tree-rings and 14C prod rate (Fig. 1; Raspopov et al., 2008) without filtering is not very convincing either. Finally, they don't use the actual instrumental sunspots data spanning the pastâĹij300 years to compare with their tree-ring records, which is a little bit curious. To be honest, I don't reject the influence of solar forcing on regional climate, but based on this paper, it does not help your interpretation of the connection between solar forcing and your site. 5b: Lines 414: "which show decadal-to centennial periodicities". The authors refer to Fig. 4 LZ II. This is an image; hard to see any decadal-to centennial periodicities. Can you make spectral analysis of these layers characterizing lithozone II to prove these periodicities? It could be challenging without i.e. μ-XRF data.

Author′s response: We agree to the reviewer and delete the discussion on solar cycles. We restrain to a pure description of the observed intercalations and point out that it remains unclear if they are related to external triggers or random processes citing the reference suggested by the reviewer (Turner et al., 2016). We also change the term “periodicities” to intercalating /recurring patterns.

5b. As we agree to the reviewer concerning the occurrence of petrographic periodicities and avoid this term in the revised manuscript, there is no further need for spectral analyses. The deposition of differing varve types showing the decadel-cenntennial intercalating pattern is purely based on varve counting. To better visualize the intercalations we add a figure linking sediment compositions and microfacies observations using XRF mapping of the varve type distribution for selected intervals of LZ II and LZ III (new Fig. 4.2).

Author′s change in manuscript: The causes for these clear intercalations remain speculative and include either external (climatic) triggers or unknown lake-internal or sedimentation variability. (Turner et al., 2016 and reference herein). Fig. 4.2 (μXRF mapping) has been added.

Referee comment: 6. In the text the authors use AD, please add AD/BC in your plots.

Author′s response:agreed.

Author′s change in manuscript: An axis of AD/BC ages is added to the plots.

Minor comments:

Referee comment: Lines 37-38: Why Lake Telmen is varvedâĹij1940-2013? Human influence (N & P) in the watershed? If so, this is not the case for your site?

Author′s response: This was misunderstood by the reviewer because the varve record from 1940 – 2013 is from Lake Sary Chelek in Kyrgystan and not from Lake Telmen. From Lake Telmen discontinuous varved intervals are reported for the time period from 4,390 cal years BP on (Peck, 2002). We clarify the sentences about other regional

varve records in the text.

Author′s change in manuscript: In Kyrgyzstan, varves have so far been only reported from Lake Sary Chelek (Kyrgyzstan) for the short time interval from ∼1940′s to 2013 (Lauterbach et al., 2019). Other varved records in the larger region are Lake Telmen in northern Mongolia which exhibits discontinuously varved intervals from approximately 4,390 cal years BP (Peck, 2002) and Lake Sugan in north western China covering the last ∼2,670 years BP (Zhou et al., 2007).

Referee comment: Figures 5 and 6: add error bars on CRS/CIC model

Author′s response:done.

Author′s change in manuscript: Error bars added in Figures 5 & 6.

Referee comment: Lines : 164-233-763 : change centimetre to centimeter

Author′s response:agreed.

Author′s change in manuscript: Line 164: The uppermost centimeter is enriched in calcite and exhibits greyish faint laminations. Line 233: Faint and discontinuous calcite laminae occur in the uppermost centimeter (Fig. 4.1 f). Line: 763: (Fig.6) Core pictures of the upper part of the composite profile CHAT12 (right) and the gravity core SC17_7 (left) illustrate the facies change to calcite-enriched sediments in the uppermost centimeter.

Referee comment: Figure 1: should add labelling to isobaths.

Author′s response:agreed.

Author′s change in manuscript: Isobaths are labelled in figure 1.

Referee comment: Line 301: laminar denudation: please describe this.

Author′s response: By “laminar denudation” we mean the superficial catchment runoff probably associated with an activation of widely dispersed smaller tributaries during precipitation events. We will clarify this in the text.

Author′s change in manuscript: Runoff with suspended sediment load is then likely directed through the Kegagyr River in the east but may also be the result of surface runoff through the activation of several and widely distributed smaller tributaries in the catchment.

Referee comment: Line 461: Why such an increase of precipitation at AD 1150? MCA? However, it seems to last until recent, so occurring in the LIA as well. A change in boundary conditions in the watershed? High-resolution grain-size analysis could shed some light about this.

Author′s response: It is correct that the onset of additional detrital sub-layers during summer started at AD 1150 but it lasted not until recent but until ca. AD 1730, about the time when varve preservation became poor and finally ceased. We do not know the reason for this increase in summer runoff events and can only state that there is no coincidence with climatic periods reported from other records (MCA, LIA). We did not carry out grain size analysis because our continuous microfacies analyses does not reveal any significant shift in grain size. Therefore, changes in boundary conditions in the catchment appear unlikely. We have revised and clarified the text accordingly.

Author′s change in the manuscript: Chapter 5.4.5revised Clastic-organic varves constitute 59 % of the observed varves in LZ V, clastic-calcitic varves 26 % and organic-clastic varves 15 %, the latter ceasing at 110.5 cm (AD 1260 $\pm$ 50). Varve microfacies changes abruptly at 130 cm depth or AD 1150 from the dominance of organic-clastic varves to dominating clastic-organic and clastic-calcitic varves. Within 5 years, varve thickness drastically increase from Ø 0.43 mm in LZ IV to Ø 1.52 mm in LZ V due to thicker summer sublayers. Thicker summer sublayers result from both thicker mixed sublayers rich in algae remains (Botryococcus, chrysophytes, diatoms) and additional late summer detrital sublayers (Fig. 4.1.e, Suppl. Fig. 2f). The increase in summer layer thickness, therefore, suggest both, higher lacustrine productivity and an increase

in summer runoff. However, the reasons for these changes remain elusive and a relation to known climatic periods like the Medieval Climate Anomaly and the Little Ice Age is not found. One might speculate that the frequent occurrence of late summer runoff layers either reflects convective rainfall events due to recycling of local moisture sources (Aizen et al., 2001), or changing atmospheric circulation regimes. Changes in boundary conditions in the catchment of the lake are unlikely since microfacies analyses does not show pronounced changes in grain size distribution of the detrital material. Human impact cannot fully be excluded but low indices of human and livestock fecal biomarkers (Schroeter et al., 2020) are an argument against major human impact. The presence of lake deposits at the northern and southern shores ca 1.5 - 1 m above present day lake level dated at AD 1420 $\pm$ 204, AD 1044 $\pm$ 160 and AD 858$\pm$ 166 (Shnitnikov, 1978) suggests that increased summer runoff might have resulted in a more positive water budget and lake level rise.

References

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