

## Author's response to Referee #2

We thank Referee #2 his comprehensive comments and suggestion that have allowed us to improve the manuscript. Below we respond to all the general comments, and we accepted all the corrections made in the attached PDF.

The Referee's comment below are in italics and our answer in bold font.

- *(1) Chronology and possible presence of hiatuses and/or unconformities in the sedimentary record. The authors do not consider at any step of the article the possibility that the record might not be complete or continuous. Considering the small-scale lake morphology (which unfortunately information on size and depth are missing), I believe that these issues definitively need to be taken into consideration. Furthermore, the authors state that when coring procedures took place, the lake size was even smaller than in previous years, testifying for the great variability such a lake system may have suffered in the past. Regarding the sedimentological record, just by looking at the lithological changes (Figs. 2 and 4) I estimate that depths characterized by sharp lithological variabilities (and that are associated with abrupt petrophysical and geochemical variations; e.g., at ca. 34 cm depth), may also result from interrupted sedimentation. I also think that the age/depth model in figure 2 is misleading as the dots in the graph does not necessary needs to be connected. Moreover, if you decide that the curve should be shown as is, so definitively a plus/minus range (such as a strip in the entire plot) should be given as well.*

**Although sharp lithological, magnetic susceptibility (MS) and geochemical changes are recognized throughout the sediment core, i.e. at 58 cm and 34 cm, we believe there is no significant hiatuses or unconformities in our record. For example, at 58 cm the lithology changed from mostly clay to peat, coinciding with the onset of an aridity trend (see section 5.1.2). Nevertheless, the calculated sedimentation rates, deduced from the radiocarbon dated samples, did not show any significant changes, for this reason we consider that sedimentation was fairly continuous. In contrast, at 34 cm the lithology changes from peat to more detritic sediments as a result of a change to more humid climate (the Iberian Roman Humid Period, see section 5.1.3). In this case, the lithology supports more erosion in the basin, enhanced sedimentary input into the lake and likely higher water level. Although a significant increase in the sedimentation rate is recorded from 44 cm to the top, we think that it is most likely due to the lower compaction of the sediments at the top of the record. Thus we consider that no hiatuses occurred during this interval either.**

**With respect to the question about the age model, the “Clam” software output gives a plus/minus range, represented in figure 2 by the gray shadow. We agree that it was difficult to see and we have made the black line thinner, which shows the age model error more clearly and we have added it to the legend in figure 2.**

- *2) The suggestion that Pb/Al is a reliable recorder for human impact in the region. I sincerely do not see any important or drastic change in this parameter that can be connected with human impact, especially not in the suggested age of \_2800 cal yr BP (Fig. 8). The authors suggest that anthropogenic impact in the environment can be identified at this time, but this assumption is definitively not sustained by the data. There is only a single peak occurring at this time and not a trend towards increase values, as should be expected. In my opinion, the change on those elements are adirect result of a local variability in the source watershed, which can also be appointed (in this case) to natural causes. Yet, I totally agree with the trend identified for the younger sedimentary sequence (\_150 years BP). The authors indeed explain the possible dilution of Pb in the LH record as a consequence of an increase catchment area and*

more humid conditions and they rely the assumptions solely on comparison with a nearby record (LdRS). I suggest the authors to abstain of reaching such a concise statement only by comparing with a single site, and neglecting that their own data does not strongly support those evidence. **We agree with the reviewer that our data is not strong enough for supporting that hypothesis. Instead of covering the last two millennia, we focused our discussion in the last 150 year BP and renamed the section. See lines 489-500. Also, we modified the Figure 8.**

- 3) Saharan dust. The idea is definitively well presented and well discussed against datasets from the African continent (although some references are missing, such as Krueger et al. *Atmospheric Environment* 38, no. 36 (2004): 6253-6261). Yet, I argue that the increase in Ca in their record (Fig. 7) does not necessary need to only imply dust coming from the Sahara. I suggest the authors to also consider the possibility that during increase intervals of Ca/Al or Ca/Ti (especially  $\sim$ 3300-2500 cal yrs ago, according to their figure), Ca elements could derive from exposed areas of continental shelves in southern Spain or Northern Africa. Those regions will probably include much greater amount of Ca, when compared with datasets from the Sahara. Please refer to the necessary literature for discussing this issue. I have made further corrections directly on the PDF associated with this letter. In light of the major comments listed above and those directly written on the PDF, I recommend the authors to carry out a comprehensive re-structuralization of their paper prior to further acceptance by the editor.
- **We agree with the reviewer that we cannot fully confirm that Saharan dust is the exclusive source of Ca in the LH sedimentary record. In fact, the correlation between Ca and Zr ( $r = 0.57$ ;  $p < 0.05$ ) suggest that Ca likely came from other sources apart from Saharan dust. Previous studies show that the Saharan dust represents the 85% of total dust input in three lowland sites between 500 and 1000 masl around Sierra Nevada (Morales-Baquero and Pérez-Martínez, 2016). Therefore, higher Saharan dust input is expected at higher altitudes since its transport mostly occur between 1500 and 4000 masl (Pulido-Villena et al., 2006; Jiménez et al., 2018). According to Pulido-Villena et al. (2006), the present-day Ca input into the nearby Laguna de Río Seco site from Saharan dust (input to the catchment area plus direct input to lake surface area) has been estimated around 190 kg Ca per year, an amount sufficient to account for the entire lake Ca budget. In addition, the Saharan dust bears others nutrients such as P and N that contribute to microorganism bloom in the Sierra Nevada oligotrophic lakes (e. g. Morales-Baquero et al., 2006, 2013). Jiménez et al. (2018) showed a relationship of the Ca content in the Saharan dust recorded in six Sierra Nevada's lakes, with the increase in *Daphnia*, which use Ca for developing its exoskeleton. Hence we consider that most of the Ca input to LH derives from Saharan dust, but we added a new paragraph in the text highlighting that other different sources could have also been involved. On the other hand, we thoroughly read *Kreuger et al., Atmospheric Environment* 38, no. 36 (2004): 6253-6261, and although it is a great summary of the different eolian dust sources around the world, we instead decided to include *Moreno et al., 2006, Chemosphere*, 65, 261-270, which summarized different African dust sources and its compositions, since they are closer to our record. See lines 288-300.**

#### References:

- Jiménez, L., Rühland, K. M., Jeziorski, A., Smol, J. P., and Pérez-Martínez, C.: Climate change and Saharan dust drive recent cladoceran and primary production changes in remote alpine lakes of Sierra Nevada, Spain, *Glob. Change Biol.*, 24, e139-e158, DOI:10.1111/gcb.13878, 2018.
- Morales-Baquero R., Pulido-Villena, E., Romera, O., Ortega-Retuerta, E., Conde-Porcuna, J. M., Pérez-Martínez, C., and Reche, I.: Significance of atmospheric deposition to freshwater ecosystems in the southern Iberian Peninsula, *Limnetica*, 25, 171-180, 2006.
- Morales-Baquero, R., Pulido-Villena, E., and Reche, I.: Chemical signature of Saharan dust on dry and wet atmospheric deposition in the south-western Mediterranean region, *Tellus B*, 65, DOI:10.3402/tellusb.v65i0.18720, 2013.
- Morales-Baquero, R., and Pérez-Martínez C.: Saharan versus local influence on atmospheric aerosol deposition in the southern Iberian Peninsula: Significance for N and P inputs, *Global Biogeochem. Cycles*, 30, 501-513, DOI:10.1002/2015GB005254, 2016.
- Moreno, T., Querol, X., Castillo, S., Alastuey, A., Cuevas, E., Herrmann, L., Mounkaila, M., Elvira, J., Gibbons, W.: Geochemical variations in aeolian mineral particles from the Sahara–Sahel Dust Corridor. *Chemosphere*, 65, 261-270, DOI:10.1016/j.chemosphere.2006.02.052, 2006.