

Referee #3 (C. Jaramillo)

With interest I have read the manuscript by Miao et al: Late Cenozoic continuous aridification in the western Qaidam Basin: evidence from sporopollen records. The Qaidam basin is a high-elevation, hyperarid basin in western China that makes part of the northeast side of Tibetan plateau. The basin is surrounded on all sides by mountains and it is a prolific producer of gas and minerals. Understanding the evolution of the Tibetan plateau is critical for its implications on global climate and the tectonics of a large part of Asia. Miao studied the palynological context of three cores, almost 4.5 km long, that cover a span of the last 18 Million years. These cores offer a unique opportunity to understand the evolution of the plateau and its results are of global interest. Miao separate the pollen record into three main categories (xerophytic, conifers and thermophilic), and based on the patterns of abundance infer that the thermophilic taxa were abundant during the MMCO, and decrease after 14 ma. At 3.6 Ma, thermophilic decrease even more and xerophytic increases rapidly, that correlates with the onset of the northern hemisphere glaciation. Since 18 Ma, the aridification has increased as a result of global cooling, and also the uplift of the Tibetan plateau contributed to the aridification of the region. However, there are major problems with this manuscript that need to be addressed before it can be published. I list them below.

1. The paper lacks proper statistical analysis. All interpretations are based upon visual inspection of the pollen abundance curves without statistical support. In order to support the interpretations the following analysis need to be done 1A. A multivariate analysis (e.g. A non parametric multidimensional scaling) of both samples and species. Confidence intervals can be done using a randomization approach (e.g. bootstrapping). What would be the analysis for? first, to test if the five distinctive floras that are interpreted in the text, have statistical support. Is that is the case, the analysis would show well defined clusters of samples in agreement with Miao's interpretation. Second, to test if the a-priori defined pollen assemblages (xerophytic, conifers and thermophilic) are supported for the data. If that is the case, the analysis should show all species clustered in agreement with the proposed assemblages. I would suggest consulting the following publications Kovach, W. L. 1989. Comparisons of multivariate analytical techniques for use in Pre-Quaternary plant paleoecology. *Review of Palaeobotany and Palynology* 60:255-282. Clarke, K. R. 1993. Non-parametric multivariate analyses of changes in community structure. *Australian Journal of Ecology* 18:117-143. Kendal, N. C. & L. Orloci. 1986. Applying metric and nonmetric

multidimensional scaling to ecological studies: some new results. *Ecology* 67:919-928. Shi, G. R. 1993. Multivariate data analysis in palaeoecology and palaeobiogeography - a review. *Palaeogeography, Palaeoclimatology, Palaeoecology* 105:199-234. Manly, B. F. J. 1994. *Multivariate Statistical Methods, A primer*. second edition. Chapman and Hall, London. Jacoby, W. and Armstrong, D.A. 2012 Bootstrap confidence regions for multidimensional scaling solutions. R package 1B. A first-differencing correlation of temperature vs thermophilic taxa, and of elevation of tibetan plateau and xerophytic taxa. The paper indicates that floras are changing following the global temperature. Paper also suggests that the elevation of the plateau is correlated to increase in abundance of xerophytic taxa. Both of these major statement need statistical support. I would advise to read the following paper Alroy, J., P. L. Koch, & J. C. Zachos. 2000. Global climate change and North American mammalian evolution. Pages 259-288 in D. H. Erwin & S. L. Wing, editors. *Deep Time: Paleobiology's Perspective*. The Paleontological Society, Lawrence. 1C. A Detrended Correspondence Analysis (DCA) could be very useful, as it could identify clearly changes in vegetation along a gradient. See Kovach, W. L. 1989. Comparisons of multivariate analytical techniques for use in Pre-Quaternary plant paleoecology. *Review of Palaeobotany and Palynology* 60: 255-282. Clarke, K. R. 1993. Non-parametric multivariate analyses of changes in community structure. *Australian Journal of Ecology* 18:117-143.

This manuscript has a great potential but still requires a substantial amount of analysis. I hope to see it published soon.

Response: Thank you for such important suggestion, we are not good at the statistic analysis above. After reading them, we are sure that the proper statistical analysis are obviously more important than visual inspection without statistical support. Besides of the related papers above we have also read several other papers about the statistical analysis. We find the detrended correspondence analysis (DCA) and principal component analysis (PCA) are the two basically usual methods for pollen analysis, including both samples and species (e.g., Zhao et al., 2009; 2012; Cook et al., 2011; Chen et al., 2013). For DCA, it is very useful to identify the length of the environmental gradient and to determine whether linear- or unimodal-based techniques should be employed in subsequent ordination analyses. The length of the gradient was 2.14 standard deviation units, suggesting linear techniques were most appropriate for our data. To summarize the data structure, PCA was performed, which made the xerophytic taxa ecologic presentation

clearly based on the analysis result of the xerophytic taxa scores. We have added these into our manuscript (please see lines 112-117; 158-175; 208-213). The results clearly show how Chenopodiaceae, *Nitraria*, Ephedraceae and *Artemisia* etc. can be defined as xerophytic taxa, so we renewed the xerophytic pollen percentages in Fig. 7a and 10a, in order to make our records more credible (please see lines 112-117; 158-175; 208-213). However, for the thermophilic percentages, after considering the PCA results, we still use the original taxa used in the original thermophilic percentages due to their natural distribution and related climate characteristics, rather than the PCA results (please see lines 227-235). Just as mentioned above, we almost ignored the statistic training until such important suggestion although we added it in the revision, if possible we will continue to improve it until it is up to the reviewer agree.

Reference:

- Yan Zhao, Furong Li, Yuting Hou, Jinghui Sun, Wenwei Zhao, Yu Tang, Huan Li. Surface pollen and its relationships with modern vegetation and climate on the Loess Plateau and surrounding deserts in China. Review of Palaeobotany and Palynology 181 (2012) 47–53.
- Cook, C. G., Jone, R. T., Langdon, P.G., Leng, M. J., Zhang, E. Z., 2011. New insights on Late Quaternary Asian palaeomonsoon variability and the timing of the Last Glacial Maximum in southwestern China. Quaternary Science Reviews 30, 808-820.
- Chen, J.H., Zhang, E.L., Brooks, S.J., Huang, X. Z., Wang, H.P., Liu, J. B., Chen, F. H., 2013. Relationships between chironomids and water depth in Bosten Lake, Xinjiang, northwest China .Journal of Paleolimnology 06, DOI 10.1007/s10933-013-9727-5.
- Zhao, Y., Chen, F.H., Zhou, A.F., Yu, Z.C., 2010. Vegetation history, climate change and human activities over the last 6200 years on the Liupan Mountains in the southwestern Loess Plateau in central China. Palaeogeography, Palaeoclimatology, Palaeoecology 293, 197-205.

2. Authors need to keep in mind that the large differences in sampling density among the three cores can affect results. In the youngest core, it is possible that the great variability in abundances could be the product of a higher sampling density compared to the mid and lower cores. To test that, a randomization (bootstrapping) needs to be performed in the upper core, to simulate the sampling density of the lower cores. I suggest consulting: Gilinsky, N. L. 1991. Bootstrapping and the fossil record. Pages 185-206 in N. L. Gilinsky & P. W. Signor, editors. Analytical paleobiology.

Paleontological Society, Pittsburgh.

Response: Yes, however we noticed the trends in the SG-3 core are unambiguous, and foremost in contrast those fluctuations. It means the sampling density seems no influence on the pollen results. So, maybe the randomization is not useful enough. Of course, if necessary we will added it in the further corrections after re-revision.

3. As a result of lack of proper statistical analysis, the manuscript is too story-telling and ideas get all mixed up. What is the main driver of the vegetation changed observed? Global temperature? the elevation of the Tibetan plateau? the intensification of the monsoon? local tectonics producing a rain shadow in the basin? Each of these questions could be tested with the pollen record presented here.

Response: Based on the proper statistical analysis mentioned above (please see the first question of this section), the story and interpretations become clearer, and we find that the global cooling is the dominant influence, followed by the tectonic uplifts and monsoon (please see the 'Discussion' section, lines 237-396). The cartoon of Fig. 11 also illustrates visually the relationships between the vegetation characteristics, climate (aridification and cooling) trends, Tibetan Plateau uplift and the Asian monsoonal evolution.

4. The raw counting data must be provided.

Response: Yes, added (Please see line 99).