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Climate of the Past Discussions



# *Interactive comment on* "Pollen-based temperature and precipitation inferences for the montane forest of Mt. Kilimanjaro during the last Glacial and the Holocene" *by* L. Schüler et al.

**Anonymous Referee #3**

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Pollen-based temperature and precipitation inferences for the montane forest of Mt. Kilimanjaro during the last Glacial and the Holocene. Schüler et al.

This paper reconstructs the climate of the Holocene and Glacial period (47-36 and 6-0.8 kyr BP) using pollen data from a short soil sediment core from the upper slopes of Mnt Kilimanjaro, Africa. Paleoclimate is inferred using a transfer function based on pollen data gathered from tauber traps at 14 sites along an altitudinal gradient.

There is a significant lack of long-term quantitative climate records, and especially temperature records, from Africa, and this study represents an important contribution. The key problem with the study however is in the methodology, and particularly the size and

nature of the calibration dataset and the assumptions therein. Some of these problems may be overcome by increasing the size of the training set, either by more extensive sampling and/or using modern surface sample data from the African Pollen Database (Gajewski et al 2001), as used in other pollen-climate studies from the region (eg Peyron et al 2000, which is surprisingly not mentioned by the authors). However, other problems such as lower glacial CO2 can only be overcome by using inverse modeling techniques, and not the modern analogue approach presented here (note that even regression methods such as WA-PLS used here are essentially modern analogue).

Addressing these problems will unfortunately require substantial work that I think is beyond the scope of the paper in its current form. I still think however that this study is of significant scientific importance, and would not want the authors to be unnecessarily discouraged, but to try and find a way to address these issues in their future work.

I set out my main reservations below. I confine myself to the more substantive issues only. There are also quite a few minor problems including language, which I do not mention here but would also need some attention.

1. The authors use a total of 28 modern pollen samples from 14 sites for their pollen-climate transfer function. I am not aware of any previous attempt to reconstruct past climate using pollen data from such a very small training set. Whilst we should make some allowance for the uniqueness and difficulties of the location, I have major reservations about the robustness of any reconstruction based on such a small training set. The authors describe some of the uncertainties in terms of the transfer function statistics, but do not acknowledge that these uncertainties are simply a reflection of the internal consistency of the training set. It is a common error in the application of transfer function software to assume that the uncertainties generated can be interpreted literally and that these capture all of the associated uncertainties. I would recommend that the authors read papers by John Birks, Steve Juggins and Richard Telford on the use and misuse of transfer functions and how to undertake the correct experimental design. The problem in this case may be greater than acknowledged because even the largest



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climate changes discussed in the paper (eg between the Holocene and Glacial) appear to relate to a difference equivalent to around 100m change in altitude. With the training set of 14 sites distributed along an altitudinal/climate gradient of around 1400m, the whole reconstruction may be driven by as few as 3-4 sites in the training set.

2. The modern pollen samples used by the authors to calibrate the transfer function come from tauber trap data. It is not explained how this is used (it should be), or how many years/months/days this was monitored for. The climate monitoring suggests 7-8 years at most. The site used for the fossil pollen record appears to be some kind of soil profile (more information needed). Significant differences have been noted between the deposition of pollen in tauber traps and other types of sedimentary environments, while the design and monitoring of the tauber trap is also important since they can be subject to errors due to heavy rainfall, insects and other types of disturbance. In any case, the trap data will reflect changes in the seasonal or inter-annual variability in pollen production of the surrounding vegetation. I would suspect monitoring would not be long enough to capture changes in the vegetation composition that normally occur over longer time-scales, particularly in the case of forests with longer lived trees. This temporal scale is important because the fossil pollen record appears to be from a very slowly accumulating site, where even a 1cm depth sample (again, sampling is not described clearly, just 'every 2cm') appears to represent something in the order of 140-150 years. The authors are therefore comparing two very different things between the fossil and modern pollen record, one the slow evolution of the vegetation assemblage in the fossil record (140-150 years), and the other the short-term pollen productivity of different plants in the modern pollen record (1-8 years).

3. The authors attempt to reconstruction 3 climate variables (MAP, MAT and Tmin). Whilst these are commonly used variables in pollen-climate reconstructions, the training set is arranged along a strong environmental gradient where all 3 variables are strongly covariant. This is also shown by the reconstruction, which shows a strong correlation between the different climate variables, which do not exhibit independent



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behavior. To separate the influence of these variables with such a small dataset of 14 sites, as used by the authors, would be virtually impossible. For instance, let us suggest that the vegetation is driven by Tmin only, and the other two variables are passive. To eliminate this possibility, we need many samples from sites with the same Tmin, but where MAP and MAT varies. As it is, without this type of experimental design, the reconstruction cannot be judged to be robust. Again, the uncertainties returned by the transfer function are unrealistic.

4. The authors do not show any pollen diagrams, either for the tauber trap data or the fossil pollen record. These should be included and differences discussed. It is important to consider whether the modern pollen data represents a reasonable analogue for the fossil record. Chord distance would be a good measure of this, as well as a visual representation in terms of diagrams. It is important to know what is really driving the climate reconstruction, since the climatic changes are relatively small and so it is suspected that the vegetation changes are also relatively small. There is also a marked 'jump' between the most recent fossil pollen sample in the late Holocene and the modern climate value. To what extent could human impact be influencing the modern vegetation? (the authors mention human disturbance of the surrounding vegetation) and what would it look like if this was relaxed, and how could this influence the climate reconstruction? is the modern vegetation a good analogue for the fossil record?

5. A key problem with the application of modern analogue approaches to pollen-climate reconstructions for the glacial period is the influence of lowered CO2 (around 180-200 ppm compared to ~280 ppm Pre-Industrial). This is not even mentioned by the authors, and I wonder if they have even considered this problem. The main effect is to increase the number of leaf stomata required, and therefore the sensitivity of the plant to moisture stress. Therefore, without any actual change in climate, the vegetation will appear to reflect increased aridity. There are also other issues, which could increase cold temperature sensitivity. This is the reason that a lot of effort has been put into



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inverse modelling as a way of getting around this problem by including the CO2 effect in the calibration process (see papers by Haiben Wu). I do not think that a purely modern analogue approach can be viewed as reliable for the glacial period.

Other substantive problems:

1. The introduction needs substantial editing. There is a lot (80%?) of unnecessary discussion of pollen-climate studies that can be removed. It is more important to include something more about the palaeoclimate of the region, previous studies, current knowledge and the important issues.

2. An age-depth model is needed, together with some discussion of possible contamination problems and dating inversions. The materials dated include bulk as well as charcoal, what is the possible influence of roots, bio-turbation etc. What is the stratigraphic reliability of the record given that it appears to be a soil profile and contains a large hiatus. For instance, influence of slope erosion, reworked material etc?

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Wu et al. (2007) Dominant factors controlling glacial and interglacial variations in the treeline elevation in tropical Africa. PNAS 104 (23)



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Wu et al (2007) Climatic changes in Eurasia and Africa at the last glacial maximum and mid-Holocene: reconstruction from pollen data using inverse vegetation modelling. Clim Dyn. 29, 211-229

Interactive comment on Clim. Past Discuss., 10, 195, 2014.



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