Solid Earth Discuss.,
doi:10.5194/se-2016-95-RC1, 2016

Solid Earth
Discussions
Open Access
EGU

Interactive comment on "Stepwise drying of Lake Turkana at the end of the African Humid Period: an example of forced regression modulated by solar activity?" *by* Alexis Nutz and Mathieu Schuster

Anonymous Referee #1

Received and published: 12 September 2016

GENERAL APPRECIATION

I reviewed two previous versions of this manuscript submitted originally to a different journal, and production of successive improvements to the manuscript has been a learning process on the part of the authors. Their decision to withdraw the submission at the other journal seems to indicate that they had lost confidence in their capacity to accommodate my remaining criticisms (and perhaps also criticisms by the other reviewer). However, the present manuscript is actually close to being acceptable for publication, except for one crucial defect in the presentation of the results that really must be corrected. I hope that my comments below will stimulate the authors to make the requested changes, such that this interesting study can finally see the light of day in print.

MAJOR COMMENTS

The study described in this paper is an original application of geomorphological data to reconstruct past climate and hydrological change in a semi-arid region of tropical Africa where detailed paleoclimate proxy records are scarce. The geomorphological analysis itself appears technically sound, but the study's significance is undermined by the rather unsatisfying paleohydrological and paleoclimatological interpretation of the data. It is exactly the innovative use of a beach-ridge sequence as paleoclimate proxy (and the way in which it may address a much-debated climate question) that is worth publishing in Solid Earth, but only if the argument linking the temporal spacing of the beach ridges to climate change is sound and robust. As currently presented the authors' central claim that the chronosequence of mid-Holocene beach ridges at Lake Turkana in northern Kenya (reflecting the lake's stepwise regression during a prolonged drying phase at the end of the African Humid Period) can be correlated with variations in solar irradiance remains far out on a limb, creating a risk that the research community specializing in African climate history will dismiss the results of this study.

However, this does not need to be its fate. With relatively minor additional analysis the present submission could improve sufficiently to be considered technically sound. With most issues troubling the original paper now resolved or accommodated, the principal problem undermining the authors' inferences is the lack of good chronology. First they correctly state that the Turkana beach ridge sequence covers the period between 5.18 $\pm$ 0.12 and 4.6 $\pm$ 0.3 ka BP (lines 84-85), i.e. a period lasting between 160 and 1000 years (lines 89-90). In previous versions of the manuscript they then proceeded to claim a prominent influence of past variation in solar irradiance on the mode of lake regression (and thus mid-Holocene rainfall variability), by noting coincidence between the number of beach steps with the number of known anomalies in solar irradiance between 5180 and 4600 years ago (and simply neglecting dating uncertainty on the start and end points of this time bracket). In reality the beach sequence interval encompasses between two and ten solar irradiance anomalies depending on whether it lasted as little as 160 years or as much as 1000 years. The leap of faith required to accept that one can take the mean duration of the covered period (580 years) to claim a 1-on-1 correspondence between five beach steps and five solar irradiance anomalies is simply too great. In all honesty, this correspondence is highly tentative, and it must be presented as such.

In the present manuscript, Nutz and Schuster try to resolve the issue by indicating the minimum and maximum duration of the chronosequence interval on the solar-activity curve (Fig. 6), and by down-playing the 1-on-1 correspondence between the mean duration of the interval and five solar-activity minima as an ‘interesting match’ (line 197). But in so doing, they resign to an equal probability of about 11% that the chronosequence interval encompasses exactly five or any number of solar minima between two and ten. Evidently, this does disservice to the data. The real solution is to calculate the probability curve for the age difference between the start and end dates of the chronosequence interval. Probability curves for the latter can be obtained by 1) rerunning the calibration of the 14C date reported by Bloszies et al. (2015) for the start of the interval; and 2) calculating the Gauss curve describing uncertainty on the end date for the interval, based on the regression between OSL and 14C dates presented by Forman et al. (2014). The probability curve for the difference will determine the % chance that the chronosequence interval covers a period of about 600 years (equivalent to 5 solar minima), versus the probabilities that it covers a significantly shorter or longer period (and thus less or more solar minima, respectively). The end result will likely assign a probability of between 30 and 40% to a 1-on-1 (5-on-5) match. This would still warrant a tentative conclusion, but at least the analysis reaching this conclusion would be robust.

MINOR POINTS

Compared to previous versions, the present manuscript has much improved on the presentation of climate dynamics and forcing mechanisms. Comments below include some suggestions for further improvements in this regard. The Acknowledgement section mentions that the authors have used an editing service to improve the English text, but unfortunately quite a large number of linguistic errors remain (perhaps due to alterations made after the proof reading?), as well as phrasing that is linguistically correct but convoluted or ambiguous.

Title: I recommend modifying to “Stepwise drying of Lake Turkana at the end of the African Humid Period: a forced regression modulated by solar activity variations?”

Abstract: Please compare the version below with the original text, and use it as reference to make textual improvements throughout the paper.

“Although timing of the termination of the early-Holocene African Humid Period (AHP) is now relatively well established, modes and controlling factors are still being debated. Here, through a geomorphological approach, we characterize the evolution of the final regression of Lake Turkana at the end of the African Humid Period. We show that lake-level decline during this period was not continuous but stepwise and consisted of five episodes of rapid lake-level decline separated by episodes of slower rates lake-level decline. Whereas the overall regressive trend can be attributed to decreasing regional precipitation associated with the gradual reduction in northern hemisphere summer insolation controlled by orbital precession, we focus discussion on the origin of the five periods of accelerated lake-level decline. We propose that these are due to temporary reductions in rainfall across the Lake Turkana basin associated with repeated westward displacement of the Congo Air Boundary during minima in solar activity.”

Lines 35-37: delete “Depending on the location”, and formulate this sentence as follows: “The mid-Holocene termination of the AHP is thought to have been either abrupt (e.g., deMenocal et al., 2000), gradual (e.g., Kröpelin et al., 2008) or time-transgressive depending on location (e.g., Shanahan et al., 2015), an ongoing debate highlighting the variable responses of proxies to dominant forcings and the complex interactions among the multiple components of the local environment.”

Lines 41-42: "…the final regressions of African lakes are presented with relatively constant rates of lake-level decline (insert refs. here)".

Line 49: delete "and well developed".

Lines 50-52: "These coastal features represent a valuable paleohydrological archive that contributes to understanding of the evolution of Lake Turkana during the AHP".

Lines 53-54: define 'forced transgression' here at its first mention, instead of on line 121.

Line 66, quantify "multi-metre".

Lines 147-148: "repeated pulses of accelerated […] emptying of a magma chamber…"

Line 163, "half-precessional forcing": to my knowledge, neither of the cited references discusses half-precessional forcing, which is a pattern of orbital forcing only observed near the equator where northern and southern hemisphere monsoon systems interact (see, for example, Verschuren et al. 2009 Nature). Clearly monsoon circulation over Lake Turkana responds to simple precessional forcing (i.e. with c.23k-year periodicity) paced by northern hemisphere summer insolation, not half-precessional forcing (with c.11.5-kyr periodicity).

Lines 187-189, rephrase as "These lakes are considered 'amplifier lakes' (Street-Perrott and Harrison, 1985) for which relatively modest changes in climate are amplified into significant lake-level fluctuation due to their specific catchment morphology." First, amplifier lakes were first defined by Street (1980: The relative importance of climate and local hydrogeological factors in influencing lake-level fluctuations. Palaeoecology of Africa 12,137-158). Recently several publications from the group of Martin Trauth in Potsdam re-emphasized their value as paleohydrological recorders. Crucially not only catchment morphology is important, but also a large catchment-to-lake area ratio so that strong lake-surface-evaporation is compensated with substantial river (and subsurface) inflows. Therefore, amplifier lakes are typical for semi-arid tropical and subtropical regions. All this deserves a few more lines of explanation here.

Line 194, “major solar activity minima”: as noted in my previous review, the amplitude of these claimed ‘drastic decreases’ in ‘insolation’ are only between c.0.02 and 0.07% of total solar irradiance. Only very specific regional climate dynamics combined with a very specific lake hydrology (cf. above) can translate this small forcing into a major step-wise lake-level decline. I repeat my plea for a well-structured argument in the paper showing that the authors understand how this connection works exactly.

Lines 211-213, rephrase as “Geomorphic analysis (i.e. trajectory analysis) revealed for the first time a stepwise lake-level decline of Lake Turkana during its final forced regression at the end of the AHP. Five rapid falls in lake level were identified, intercalated with periods of slower lake level fall. We suggest that the. . .”

Interactive comment on Solid Earth Discuss., doi:10.5194/se-2016-95, 2016.

Printer-friendly version

Discussion paper