Climate of the Past Discussions

Clim. Past Discuss., author comment AC1
https://doi.org/10.5194/cp-2021-185-AC1, 2022
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Reply on RC1

Léa Terray et al.

Author comment on "The use of paleoclimatic simulations to refine the environmental and chronological context of archaeological/paleontological sites" by Léa Terray et al., Clim. Past Discuss., https://doi.org/10.5194/cp-2021-185-AC1, 2022

We would like to thank the reviewer for the detailed suggestions in the manuscript. They allowed us to better identify the reasons for the lack of clarity in our article and some of the stong comments. We apologize for it, and hope that the proposed revision address the concerns.

(1) as stated by the authors, the grid resolution of the climate model used is 157 km, which is a very coarse regional climate for comparison with a sequence

The model grid we use is a standard grid for global paleoclimate simulations and climate change experiment. Compared to other models with higher horizonral resolution the vertical resolution higher. However it is true that the model and the cave sequence do not depict conditions at the same scale. However, in nature, when considering large changes in climate as we do here between different climatic periods, the global climate conditions at least partly determine the environment at local scale. Thus, the provided information is not independent. In addition, any paleoclimate regional simulations would require the input of a large scale paleoclimate simulation and thereby represent the same large scale climatic differences between the different climate. We also use a model version that has some skill in reproducing the climate in the region of interest. Our intention was not to consider the large scale climate and the specific climatic conditions at the El Harboura 2 site as providing equal information, but to test the consistency between them, and to deduce from it potential implications for the chronological and paleoenvironmental context of El Harhoura 2.

(2) there seems to be a serious problem with the dating (or chronology) of the geologic sequence, which may lead to incorrect comparisons with each time slice from the model

Date a stratigraphic layer is not an easy task. Dating discrepancies are common in archeological context when several dating methods are used, mainly because they do not rely on the same proxy. Each present different benefits and limits. The OSL method is based on the sediment (quartz grains). It is usually pretty reliable, but it's not a straightforward technique. The combined US-ESR method is based on fossil teeth. Conversely to OSL datings, it is a direct technique, but it can be of lower resolution. The AMS-14C method rely on radiocarbon measurements. It is highly reliable to date recent stratigraphic layers, but not at all when applied to older layers.

For these reasons, it is quite normal to observe discrepancies between methods. What remain to decide is which method (i.e. which proxy) provide the best dating estimation regarding our site. This is precisely one of our objective.

Moreover, several studies have dated the stratigraphic layers of our site, providing repeatability for the dating estimations, and ensuring that the dates we used here are not likely to be biased by bioturbation or other taphonomic factors (e.g., Ben Arous et al., 2020a, b; Janati-Idrissi et al., 2012; Jacobs et al., 2012; Marquer et al., in press; Nespoulet and El Hajraoui, 2012). Because the geochronological context has been well studied, our site is a good model to test this bi-disciplinary approach.

(3) there is no quantitative climate reconstruction from the geologic sequence that could make the data-model comparison accurate

One of our objective is precisely to test the consistency between the climatology describe by the climate model and paleoenvironmental indicators from our site over the sequence. In other words, to test the coherence between atmospheric conditions at large geographic scale and the landscape and environnemental conditions at local scale.

The paleoenvironmental indicators we used are from the stratigraphic sequence itself. The THI (Taxonomic Habitat Index) is inferred from de microfaunic assemblage of the site, and the isotope survey rely on the study of micromammals teeth from the site. These indicators give quantified information about the environnemental variation over the sequence. They are usual approaches in archeology to quantitatively and qualitatively reconstruct paleoenvironments.

(4) there is a serious problem with the temporal resolution of the geologic sequence, since there are only 7 (or 8?) samples over a period of about 100,000 years. In addition, the ages seem dubious when comparing the different dating methods

The stratigraphic resolution is unfortunatly conditionned by the stratigraphic record. Moreover, a site with eight well defined, studied and dated levels are quite rare. First, because archeological sites as rich as EH2 are not common at all, and secondly because it requires an enormous amount of work to set the taxonomic, chronological and envrionmental context of a site (Ben Arous, 2019; Jeffrey, 2016; Stoetzel, 2009).

The queries about dating methods have been addressed in (2).

(5) overall, it is difficult to see how the use of a climate model has helped "refine the paleoenvironmental and chronological context of archaeological and paleontological sites," as the authors explain. The authors discussed more problems with their data-model comparison than benefits their approach brought.

It is true that, out of caution, we have extensively discussed the limits of our approach. Nevertheless, there is two major findings. First, the climate sequence describe by simulation is clearly more consistent with the paleoenvironmental indicators when we rely on datings performed with combined US-ESR than OSL. This provides substantial support for combined US-ESR datings, thus refining the chronological context of our site. This is an important result, knowing that, until now, there was no method capable of discriminating between these dating techniques on our site. Second, the climate sequence allowed us to discuss the few environmental inconsistencies existing between the paleoenvironmental indicators (THI and isotopes) by informing us about the climate trends at large scale, thus refining environmental inferences.

We hope that these precisions can clarify the objective of our article, and support the relevance of our approach. Following the suggestions of both reviewers, we propose a rearrangement of the plan of the manuscript in order to improve its clarity:

- Introduction

We will more clearly state our objective, the different issues we aim to address and the approach choosen to achieve it. We will also better present the limits that are usual and inevitable in archeological context.

- Material and Methods

This part will be recentered on the newly produced simulations using LMDZOR. Several figures currently presented in the results part will be placed here to support the clarity of the reasonning. Pre-existing simulations will be less detailed. We'll present how they were run, because using the same forcings for the LMDZOR simulations, but we'll do not named them and will just refer to the period they represent We will focus on the fact that they have been running using from different model versions, that present different systematic biases. This will be illustrated by comparing the sea surface temperature of historical simulations of each model with observations (Fig2). Fig 3 and 4, illustrating the impact of these biases on the climatology will be passed in supplementary material. We will then present the bias correction we realized in order to reduce this systematic bias between model versions. As a reference model version, we choose CM6A which is the best model version for our region of interest, as illustrated by FigA2 that will be placed in the main text.

- Results

In this part, we will directly start by presenting the results of the new simulations (Fig 5 and 6). We will add a paragraph and a figure explaining the regional and global response to the forcings behind the climate variation found on our region of interest. We'll add a figure illustrating the dynamical changes inspired from Fig 1rep attach to this response to better stress how temperature, moisture and wind lead to the changes over the NW Moroccan region.

- Discussion

We will focus on the significant results of the consistency of the different proxies, and less on the different biases that have already been presented in the introduction. Further discussion about the interpretational meaning of the correlations between climate variables and paleoenvironmental proxies will be included. We also propose to more explicitly state the major results on which our conclusions are based, and present the perspectives they offer for future works.

We will also to seriousely consider all the constructive comments and suggestions the reviwer has made in the pdf manuscript and submit the paper to English proof-reading.

Please note that substantial changes have already been made in the manuscript since its submission, notably english improvement and clarification of the material and methods.

Best regards,

Léa Terray, on behalf all authors

Please also note the supplement to this comment:
https://cp.copernicus.org/preprints/cp-2021-185/cp-2021-185-AC1-supplement.pdf