

Response to Reviewer 3:

This manuscript presents novel proxies for Indian winter monsoon variation from a core in the northeastern Arabian Sea and suggests that the intensified winter monsoon would contribute to the metamorphosis of the Harappan civilization from urban to rural society. The causal relationship between climate change and civilization has always been a question at debate due to lack of robust evidence. The variation in the winter monsoon and the distribution of the Harappan civilization archaeological sites in this paper is a great effort to answer this question. I support to be published the paper. However, there are some questions that the authors should address in next round of revision.

[We appreciate the reviewer's comments and suggestions.](#)

The manuscript is not written in a very clear way, which make readers hard to follow what the authors said. For example, in figures 3-5, all the curves should be marked by such as a, b, c, etc., and in the text it is easy to cite such as “Fig. 3c” to indicate the exact curve, but not such as (Fig. 5; Dixit et al., 2014) in Line 425.

[We addressed this problem as suggested.](#)

The reference list should be carefully checked. Almost all references have some format problems or mistakes. For examples, Lines 516-518, use pp. to indicate pages, Lines 519-521 the pages are used “959-962”. Also, the authors cited many published records in discussing Figure 3, but not showing any of them in the reference list. Readers and reviewers do not know what the authors discuss and compare when reading Line 259 to 322. Please check all the references in the References

[Done. However, we found no missing references that are cited in figure 3. If the reviewer identified such references we would appreciate if he/she can point them to us.](#)

It seems to me that the authors overinterpreted the records, though the proxies for winter monsoon variation is reasonably sounding. For example, the authors stated that the core top missed (Line 161-162). However, the authors put much effort in discussion on LNA (Line 335-345) while not showing any records from this core. Actually, the Factor 1 data do show many data points since 2000 years, which does not show the LNA though the authors claimed that Factor 1 reflects temperature change. Please explain why.

[We discuss LNA based on cores nearby where it is well attested – Dooze-Rolinski et al. for temperature, Böll et al and Munz et al. for mixing. This was clear in our original text: “Another cold yet variable period in the northern Arabian Sea \(Dooze-Rolinski et al., 2001\) occurred after ~1500 years ago under strong winter monsoon mixing \(Böll et al., 2014; Munz et al., 2015\) and is seen in *G. falconensis* record of Schulz et al. \(2002\) but is not captured completely in our top-incomplete record.”](#)

I am not convinced that changes in land cover and land use would affect movement of ITCZ. Please explain in detail. Does the authors mean the regions affected by heavy rains, which is not necessary the ITCZ?

Previous studies cited show that landcover and landuse can affect the ITCZ using both modeling and data – e.g., Chung and Soden, 2017; Devaraju et al. 2015; Kang et al., 2018; Smith et al., 2016.

The authors raised a very important question at the beginning in Introduction, “Moreover, our knowledge of temporal and spatial climatic patterns remains too restricted to fully address social dynamics” (Line 59-60). However, I did not see the authors address this question later in text other than discuss a little bit on interhemispheric temperature gradients.

We do show that ENA is detectable in the northern hemisphere (and now added references for a couple of cases in the southern hemisphere). This describes a novel temporal-spatial pattern affecting the winter rain in our region and suggests a “pull” factor for the Indus people’s migration. We now added a sentence in the conclusions to link to this point made in the introduction.

It reads: “Ultimately, ENA is a synoptic pattern that provides a framework to address the role of climate in interacting with social dynamics at a scale larger than the Indus domain. As such, if ENA affected human habitation of the entire eastern Northern Hemisphere, and particularly in the Fertile Crescent and Iran that also depend on winter rains, remains to be assessed.”

The authors put much effort on distribution of Harappan sites, but did not show in any figures. It would be easier for readers to have a figures showing the distribution of the sites.

We will add a supplementary figure addressing this.

Why the numbers of data vary so much for Factor 1, 2 and 3? Please clarify in the text.

The number of data for factors (black curves in Fig. 2) is the same for all factors (see also Suppl. Table 4). They are compared with other parameters (sea level, chlorophyll proxy, temperature) that each have their own resolution.

Affiliations: should be consistent for all addresses. Some list to department, while others only list the university.

Done.

Introduction: The logic in Introduction is not clear. Please revise following clear logic.
Abstract: The Abstract is not clear. For example, Line 32-34.

These comments are unfortunately too vague. What one person might find as logic someone else might not. We would be happy to address them if clarified.

The authors did not label various panels in figures clearly, which makes reading difficult. Please label the panels and cite in the text.

Done.

The temporal resolution for samples should be clearly addressed.

Unclear what is requested. Temporal resolution is variable depending on sedimentation rates. Data is all documented in tables at the depth/time resolution available.

What is Calib 7.129? (Line 159)

This was a mistake – it is the Calib 7.1 calibration program – corrected and citation added.

Line 272, should use “cal years BP” or “years” without “BP”. Please check the whole text.

We prefer to keep “years ago” throughout – now changed.

Line 312, should be “3,000 years ago”

Done.

Figure 1: Please check the arrow of “summer monsoon”. The direction should be wrong.

The arrow indicates the direction of moisture reaching the area of interest during summer monsoon, which is from the Bay of Bengal. That is now made clearer in the caption.

Caption reads: *Fig. 1. Physiography and precipitation sources for the Harappan domain. The dominant source during summer monsoon is the Bay of Bengal while western disturbances provide the moisture during winter. The extent of the Indus basin and Ghaggar-Hakra (G-H) interfluvium are shown with purple and brown masks, respectively. Locations for the cores discussed in the text are shown.*

Figure 3-5 quality is not high. Please improve them.

If the reviewer refers to the resolution of figures this will be improved in the final version. The submitted figures for the review stage have downgraded resolution to get the manuscript at a manageable size. We also implemented some color changes to increase readability.

Figure caption. Figure 1, there are three colors in the figure 1 but not two. Please change the figure or the caption; Figure 4, Line 921, better to give the full name of “ENA”. Figure 5, Line 943, change “of Dixit et al. (2014)” to “(Dixit et al., 2014)”

Done.