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Interactive comment on "Circum-Indian ocean hydroclimate at the mid to late Holocene transition: The Double Drought hypothesis and consequences for the Harappan" *by* Nick Scroxton et al.

Anonymous Referee #1

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Scroxton et al. present an age-uncertain MC-PCA analysis of 10 speleothem records and 3 sediment records from the circum Indian Ocean basin, and discuss the results in the context of hypotheses driving the decline of the Mature Harappan period of the Harappan civilization. A specific focus of the discussion is evidence for a "4.2 kyr event", which has been hypothesized to drive the decline of the Harappan civilization.

The paper is well-written, presents an interesting new analysis, and has the potential to be an important contribution to the literature. I do have several major points that need to be addressed before I can recommend the manuscript for publication:

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Major points

1. The MC-PCA analysis is state-of-the-art, but the spatial component of the results go largely unpresented or discussed. This is especially the case for PC2, given the mix of loadings, but even the spatial patterns of the strength of PC1 could shed light on the question at hand. I suggest the authors add maps that illustrate the PC1 and 2 loadings, and their uncertainties, and discuss their results. This is particularly important for PC2. The authors describe this as a dipole that represents a fluctuating wet and dry signal. The spatial structure of this dipole, especially as it relates the the Harappan civilization, needs to be presented and interpreted; including a discussion of the age-uncertainty, and record selection uncertainties (PC-1,-2,-3).

2. From the analysis, primarily the gradual decline of the summer monsoon recorded by PC1, the authors propose a "Double-drought" hypothesis, that suggest that the combination of a shorter term (300-yr-long) winter precipitation drought, followed by the monsoon weakening beginning around 3.9 kyr weakening summer precipitation may have driven the collapse. This hypothesis is reasonable, and is supported by the MC-PCA analyses, a synthesis of Harappan archeological sites, and a single speleothem record from Italy (RL4) interpreted to illustrate the decline in winter precipitation in India. The contrast between the first two lines of evidence, and the Mediterranean speleothem is striking, especially given the importance of winter precipitation in the double-drought hypothesis. Unlike the analysis that went into summer precipitation, only a single record (RL4) is shown to draw inference about "Mid-latitude Mediterranean Climate", with a notably different age model than that used in the original (2016) publication. To defend the "Double-Drought" hypothesis, the authors need to better characterize Mediterranean climate, and its relation to winter precipitation on the Indian subcontinent. The paragraph from 359-361 states that this is broadly consistent, but this needs to be robustly established. I recognize that this is a significant request, but it would be ideal to see an analysis, either new or from the literature, of multiple records from Mediterranean (if that is indeed the best way to estimate winter precipitation in India),

that handles age uncertainty and disagreement between records. As is, it's difficult to evaluate the hypothesis when this key line of reasoning is so poorly supported.

3. In new studies that rely on syntheses of multiple records, it's critical that the data (and ideally the code) used to conduct the analyses is available, and replicable. Data that are only available upon request are not publicly accessible, and I strongly encourage the authors to archive the data used in the analysis in a public data repository. If they cannot, the authors need to explain why they cannot follow the best practice recommendation in the "Data availability" section.

4. Why is PC-3 truncated? Looking at the data in figure 2, the three sedimentary records span the full length of PC-1, and PC-2. This decision needs to be explained and justified.

Detailed points:

38-39: Awkward to say "increasingly recognized", and then have only references from 2003 and 2004.

115: "Between the records"? Do you mean between the ages?

116: Upscaled. Might be better to say "degraded".

140-144: Why? It seems easy enough to use identical ensemble members each time through. More importantly, can you justify treating multiple records from the same core as independent climate records?

172: I suggest you start by describing this as a dipole, and then describe it as fluctuating wet and dry.

178: I don't think you can call this a dry period in PC2, since it's a dipole, it must be dry some places and wet others. In general, the spatial characteristics of PC2 should be fleshed out.

294: 4.26 to 3.97 kyr BP this is a lot of precision, where do these numbers come from,

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and what are their uncertainties? This is comment relevant throughout the discussion.

309: What does this analysis say about whether the mature Harappan occurred during a short term pluvial?

314: “was likely caused by a reduction in western disturbances that bring rainfall from the Mediterranean and Middle East (Figure 6c). “ How do you know this?

Figure 1. Add Harappan sites Figure 5. Is this the ratio of winter to summer? Or the fraction that winter represents out of total rainfall. Also, an overview map showing where this is would be helpful for those less familiar with the region

Figure 7. The d) label is a little hard to locate. Consider moving it to the top left corner.

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