

## ***Interactive comment on “Summer precipitation reconstructed quantitatively using a Mid Holocene $\delta^{13}\text{C}$ common millet record from Guanzhong Basin, China” by Qing Yang et al.***

**Anonymous Referee #2**

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The authors presented carbon isotope data from fossilized common millet seeds collected from archeological sites in northern China. The carbon isotope record was then used to reconstruct summer precipitation during the mid-Holocene, on the basis of the relationship between millet C isotopes and summer precipitation established in a modern process study by the same group (Yang and Li 2015). The authors then used the reconstructed summer precipitation to discuss East Asian summer monsoon dynamics.

I find the idea is intriguing and potentially promotes the use of abundantly available millet seeds as a paleoclimate archive in this part of the world. The modern process investigation as presented in Yang and Li (2015) is an excellent study that shows a robust relationship between  $\delta^{13}\text{C}$  and summer precipitation, despite that I don't fully under-

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stand the mechanism (it is counterintuitive that lower summer precipitation correlates with lower  $\delta^{13}\text{C}$  values).

However, I have issues with both presentation and interpretation of the results.

1. I find that the “conventional” climate reconstruction and interpretation as presented in Figure 4 are unsupported, mostly due to the high variability of the record (including the instrumental climate data!), low resolution, and short, snapshot nature of the record (only cover 8-3.5 ka). The high precipitation variability at present in the study region suggests that 3-5 seeds used in each analysis just captured at most 3 to 5 years of precipitation – too small a sample size to capture mean precipitation. As a result, I don't think the correlation as presented in Figure 6 and monsoon discussion is supported.

However, I wonder if that the data set (especially an expanded data set from the region) can be used to document and understand the summer precipitation variability during the Holocene or part of the Holocene. The science question could be: is there increasing summer precipitation variability from the early Holocene to late Holocene, when the summer monsoon and precipitation decline during that time period? Is it possible that not only summer precipitation decreases during the Holocene but also becomes more and more variable and less and less predictable? The data as presented in Fig. 2a seem to suggest that, though the number of analysis is still low. I wonder if a future expanded study can analyze a larger number of samples per sample (say 30-40 seeds, preferably single seed analysis) to capture the decadal/centennial (depending time resolution) variability in summer precipitation, even just in a few time intervals (early Holocene, mid-Holocene, and late Holocene). Each individual seed is a product of a single season/year – as clearly argued and implemented during 2008 in Yang and Li (2015). This is similar to a study on oxygen isotope analysis of individual foraminifera from deep marine sediments to document ENSO variability (and annual seasonal cycle) at a few time intervals during the Holocene.

I suggest that the authors should focus on the variability rather than mean climate

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(precipitation).

2. The writing in general is clear – I commend the authors' effort to make it an easy read. However, I find there are many superlative words to describe the results, and some of these are overstatement. I will provide examples below in my specific comments.

Specific comments: Title: -focus on precipitation variability? -change "China" to "northern China", for international readership?

Abstract -add latitude (34.5 N) and perhaps rounded longitude as well, for international readership?

-there are many superlative descriptors here in the abstract, such as "accurate" (line 17), "robust" (line 19), "reliably" (line 26), "precise" (line 28). It seems to me none of these is needed and justified. Most of similar words should be deleted throughout the text.

-the abstract needs to refocus if the authors accept my suggestion above.

Introduction -It is unnecessarily too long. In particular, the general discussion on Holocene climate in the first 3 paragraphs on page 1-2 is not really needed. Delete or shorten.

-superlative word examples: "accurate" (l 41), "more completely and accurately" (l 60), "robust" (l 135).

Line 91: change "between 5.2-4.3 ka BP", to either "between 5.2 AND 4,3 ka BP", or "at 5.2-4.3 ka BP" (there are other cases of matching ". . .and. . ." in the text)

Methods This section reads well.

Line 156: I wonder if a single seed is large enough for C isotope analysis, but multiple seed analysis still can be used for the variability study as suggested above (but it will be "conservative" reconstruction of precipitation variability, due to averaging of multiple

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years growth in one sample).

L 169: "1 $\sigma$ " = 1 sigma? (67% probability?)

L 179: change to "the sampled culture layers" ("section's" is awkward usage)

L 181-186: unclear how it was done.

L 189: delete "ref."

L 190: delete "," before "demonstrated"

Results L 209: change "eliminating" to "without considering"

Line 207-214: I'm confused here. You describe carbonized Neolithic seed remains and modern common millet, but you compare "modern seeds" in the last sentence. Also, millet is more negative than seeds, rather than "positive" as described. Check.

L 233-235: "slightly higher" and "a much more humid" is contradictory. Overstatement/over-interpretation?

Discussion As I commented above, the mean precipitation reconstruction doesn't allow for much comparison and discussion on summer monsoon, while precipitation variability is potentially a novel aspect of paleoclimate research. Although your current data are not robust enough, it seems to me that it holds great promise for the future project: even just 3 or 4 horizons, with large analysis per horizon.

L 341: change "1961-2011" to "1951-2011"? which makes 60 years and also is consistent from description earlier.

Conclusions L 392-393: "low resolution" and "convincing" are contradictory.

Tables Table 1 -move latitudes and longitudes from Figure 1 to new columns here

-what "source" means here? "12" here means "12 culture layers"? if so, spell out.

-change "No." to lower case and italic "n" (to indicate number of analyses or samples)

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Table 2 -Change heading to “AMS 14C dates” (“dating data” is unusual”)

-why does a 250-cm-long section (such as BN) have the same or reversed ages? Very rapid accumulation of these layers? I hope it is discussed elsewhere in archeological literature.

-change the heading of column 4 to “AMS 14C date (yr BP)” – it is wrong to say 14C date as “cal yr BP”

-maybe a footnote to indicate the dating lab for OZM

Table 3 -maybe indicate ages as “calibrated ages” to avoid confusion

-add footnote to indicate “ $\delta^{13}C_{org}$ ” and “ $P_{s}$ ”

Figure 1. -move latitude and longitude to Table 1

-CoreIDRAW12 is not needed to mention, as it is just a map.

Figure 2. -need more explanation about panel a (raw data points) and b (box plot) in figure caption

-again Fig. 2a kind of shows increase in precipitation variability from 8 ka to 3 ka. Have you tried a regression of all the data to see if there is a significant decline (in precipitation) during that period as well? (perhaps the number of data points are still low)

Figure 3 -indicate reference in figure caption “Modified or data from Yang and Li (2015)”

Figure 4 -Again, I don't think it is a good way to present the data as groups to get mean climate/precipitation – considering the large variability almost nothing can be concluded here (a.k.a. the pattern is not robust/convincing, because of uncertainty). See my comments above.

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