

Interactive comment on “Millennial-to-centennial patterns and trends in the hydroclimate of North America over the past 2000 years” by Bryan N. Shuman et al.

Anonymous Referee #1

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The paper presents an interesting new synthesis of a large paleo hydroclimate dataset for North America during the past 2kyr. The objective is to identify the spatiotemporal patterns and magnitude of changes in centennial and millennial-scale variations in hydroclimate. Contrasts are drawn between hydrologic changes in the MCA versus the LIA, and between the first and second millennia. A variety of exploratory analyses are conducted using cluster analysis, EOF/PCA, and GLMs. Results show a wetting trend at most sites, but some regions showed a drying trend. Differences exist between the MCA and LIA, but are largely part of longer-term trends. Overall, there is very high spatial variability across the sites, and almost no regional coherence, but distinct temporal trends emerge from the data.

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The paper is clear and the findings consistent with the data, but the present design raises some questions about the approach. The approach is generally inductive and bottom-up, but a primary component of the analysis is focused on regions, which is not well justified. Regions are imposed on the data without explanation about how they were determined. And in fact, the data and analyses conducted seem inconsistent with the regional approach given that the results from the cluster, EOF, or epoch analyses do not yield clearly identifiable or coherent spatial patterns. As a result, the PCA-by-region analysis does not seem appropriate, as the trends in different regions are very similar in several cases (e.g. NE US and Mid-continent, or the Arctic and PNW). There is also no discussion connecting the paleo data to modern spatiotemporal patterns in hydroclimate. As a result, the paper lacks context, raising questions about how the spatial patterns in the reconstructions compare with current observations or historical variations in precipitation or moisture availability.

Given that the study includes many calibrated records (27%), the analyses also raise the question of whether this subset of records alone might provide a more coherent representation of change than the broader dataset. It would be helpful to resolve this in order to help motivate (or constrain) future research. A related question is whether there were differences in the annual precipitation reconstructions based on the fossil pollen records versus those used to reconstruct changes in effective moisture. It seems plausible given that one could expect quite different patterns to emerge from these two types of reconstructions depending on temperature variations.

Last, although the stated emphasis of the synthesis is on records that primarily capture multi-centennial trends, the decision to include ice accumulation but not tree-rings seems somewhat arbitrary, especially when the objective is to characterize hydroclimate from N America, while omitting one of (if not the) most important data sources of such information from the analysis, especially when it is publicly available. Thus it is not possible given the current study design to know how variations in these results compare with those in drought characteristics (e.g. location, severity, frequency, duration),

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a key component of hydroclimate.

Specific comments:

Pg 3 line 16: "Most of the record have been calibrated to a specific hydrologic variable. . ." seems to contradict the prior statement on line 1 "Twenty-five records (27%) provide calibrated reconstructions of hydroclimatic variables). . .". Although there is a contrast between hydrologic and hydroclimatic, the units (e.g. millimeters of precipitation versus "annual precipitation") are the same and thus the terminology and differences could use some clarification.

Pg 5 line 25: How does SSA estimate missing values? Please add some detail given the importance to the methods and the fact that this is a common problem in paleo studies.

Pg 6 line 14: How were the regions defined? How was PCA conducted on regions that appear to have only one or two sites?

Pg 6 line 18: What does "hydrological interferences" mean? (inferences?)

Pg 7 line 2: Top dendrogram cluster is green (not blue), no? Maybe refer to clusters by their color, or label the clusters to avoid ambiguous refs (e.g. "in one of the clusters. . ." (pg. 6, line 29).

Pg 7, line 5: There does seem to be a clear trend in 2C. It is visible in the heat map also as shifts from wetter to drier (opposite from the red clusters/panel D) though weaker. Standardize the y-axes?

Pg 10, line 14: this one sentence refers to complex hydroclimate but leaves one wondering what patterns at all exist in the modern or historical data, and in need of more information about the complexity to evaluate or make sense of the paleo data. This paragraph also raises the question of whether the authors considered elevation or other physical drivers or spatial patterns.

C3

Pg. 11-12 Section 4.3. This discussion section is lacking information about the regions. Only the PNW is discussed and several other regions are not even mentioned. If the regional approach is retained, more lit review and discussion is needed about each of the regions to give meaning to the new results and aid interpretation.

Pg 12, line 1-2, add info about what the temperature trend was (i.e. cooling) to clarify sentence.

Table 1 - Some information about the number and types of dates at least (and source materials, and error if available) would be helpful for understanding how much uncertainty is coming from dating of the records.

Figure 1 – the site map is not very legible as the symbol sizes are too large relative to the land. Also, why are nine regions marked but only six appear in the PCA (Fig. 5).

Figure 2 - indicate wet versus dry conditions on panels B-D. Also, for panel B-D, it would be helpful to standardize the axes so it easier to see weak/strong trends. For panels E-G, the lat/long grid is much less important than the site details – a rectangular bounding box would allow the land area to be enlarged to better show more of the site numbers, which are currently mostly illegible.

Figure 4 – perhaps show the distribution of values below each map to emphasize whether more sites are showing drier or wetter conditions. It is difficult to see any pattern in these maps, or to know whether any apparent clusters are meaningful.

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C4