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Interactive comment on “Spatial and temporal variability of Terminal Classic Period droughts from multiple proxy records on the Yucatan Peninsula, Mexico” *by* Stephanie C. Hunter et al.

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Hunter et al. compile previously published proxy records and perform statistical tests (namely changepoint analysis) to provide evidence for drying in the Yucatán Peninsula during the TCP.

In short, the manuscript provides a background discussion of (i) previously proposed causal forcing mechanisms that may have triggered the TCP droughts, and (ii) the previously published proxy records and their limitations. Subsequently, the manuscript goes on to discuss (i) the link between migration of the ITCZ and TCP droughts, (ii) the spatial and temporal variability of the droughts.

The results produced by Hunter et al. show that there are key differences in the spacial and temporal drying signatures in the proxy records. Comparison of the data to changepoint analysis conducted on PDO, ENSO and AMO signals led the authors to conclude that the position of the ITCZ was not the sole driver of the TCP droughts.

Whereas the idea of a coherent interval of drought across Mesoamerica has been explored in previous studies, the authors describe this manuscript as “novel” in its attempts to “(a) minimize uncertainties inherent to individual proxy records, (b) identify any regional patterns, and (c) explore temporal shifts in drought occurrence during the TCP”. However, a large proportion of the theory and analysis presented in the manuscript has been extensively discussed in previously published literature:

1. Bhattacharya et al. (2017) synthesise regional proxy records to suggest that there is statistically robust evidence of drying between 800 and 1050 CE. By studying control simulations of two general circulation models (GCMs) and the major modes of climate variability (e.g. ENSO, NAO, etc), the authors also suggest that the pattern of drying may be diagnostic of hydroclimate changes associated with multidecadal variability in the Atlantic Basin. Overall, both the proxy analysis techniques and discussion points are very similar to those utilised by Hunter et al.. Critically, however, Bhattacharya et al. (2017) provide a much more in-depth review of literature proxy age models (using Bayesian age modelling) and causal drought mechanisms (specifically by using GCM control simulations to analyse the processes that produce long-term droughts, including PDO, ENSO and AMO signals). Note that this paper is not cited in the text.

2. Douglas et al. (2016a) provide an in depth review of previous proxy records, and perform z score analysis to highlight any deviation of individual proxy measurements from the mean value of a record. Douglas et al. (2016a) observe two distinct dry intervals, at 770–950 and 1000–1100 CE, separated by an intervening period of relatively wet conditions, as well as spacial variability between records (also see Douglas et al., 2016b).

3. Evans et al. (2018) also use Bayesian age modelling and the 'Events' function in R to quantify drought timing in multiple proxy records, and provide a robust method to quantify the drought at Lake Chichancanab, one of the sites highlighted by the authors. This paper is also not cited in the text.

Could the authors elaborate as to how their manuscript provides a significant advance to the papers and analysis listed above?

Points that would significantly enhance the manuscript:

1. The use of published age models and the assumption they are accurate (which is highly unlikely) is critical to the subsequent comparison of the data to changepoint analysis conducted on PDO, ENSO and AMO signals. As a bare minimum, Bayesian age analysis should be used to quantify the errors in the age models. Sites with <5 radiocarbon (or other) dates in the last 2000-year interval should not be used (see Bhattacharya et al., 2017).

2. Each data set used by Hunter et al. spans a different range of calendar dates; thus, the mean values for each data set derive from different time intervals and may slightly bias interpretations of drought intensity inferred from the changepoint analysis in each record. This should be discussed in addition to Section 4.3, as well as in relation to the 20% uncertainty associated to the changepoint analysis.

3. Note that records of gypsum or calcium carbonate concentrations in sediments should be excluded from changepoint analysis: because mineral precipitation occurs at a chemical threshold (on/off) related to the saturation state of gypsum or carbonate minerals, these records are likely not linearly related to the magnitude of reductions in rainfall. Also, these records do not record wet climate intervals, as periods of wetter than average climate do not cause changes in mineral precipitation (Douglas et al., 2016). Additionally, tree rings records should also be excluded as existing records from Mesoamerica generally reflect early spring rainfall, and may reflect a distinct climatic signal from that recorded by speleothem and lake records (Bhattacharya et al., 2017).

4. The lack of statistical linkage between the analysis of (i) the proxy datasets and (ii) the modes of climate variability means that the assessment is only qualitative. After the points above have been considered, statistical test should be used to quantify the likelihood that PDO, ENSO and AMO signals are forcing drought conditions (see see Bhattacharya et al. [2017] for further discussion of mechanistic linkages).

5. A full discussion as to why there is a discrepancy between the Chaac and Yok I speleothems would provide useful insight (building on the explanation of Douglas et al., 2016b), as well as comparison of the statistical techniques used in this manuscript and the paper of Bhattacharya et al. (2017).

6. Section 4.3 adds little to the discussion, especially given proxy "uncertainty" is discussed earlier in the text. Indeed, the importance of the proxy dating errors (see above) means that the discussion in this section should be considered prior to statistical analysis.

Other points to note:

1. Lines 170-184: Please see the paper by Evans et al. (2018) who used triple oxygen and hydrogen isotopes of gypsum hydration water to provide the a robust, quantitive estimate of precipitation changes during the TCP and deconvolve relative humidity and rainfall.

2. Lines 185-191: Note that lake level records are sensitive to E-P. In contrast, speleothem records are generally interpreted in terms of the 'amount effect' with isotope ratios covarying with the amount of annual precipitation.

3. Lines 201-203. The largest uncertainty with the record of Medina-Elizalde et al. (2010) is the relatively poor correlation (low rˆ2 value) in the modern calibration period, as well as the fact that the magnitude of δ18O variability in the Chaac record spans a much wider range than the magnitude of δ18O variability from the recent calibration period (see Douglas et al., 2016a).

4. A clearer structure in the results section (e.g. segment the proxies by geography) would help the reader.

5. The use of qualitative language (e.g. line 364: “a bit less certain”; line 392: “more certain“ etc) should be replaced by quantitative results.

References:

T. Bhattacharya, J. C. H. Chiang, W. Cheng, Ocean-atmosphere dynamics linked to 800-1050 CE drying in Mesoamerica. Quat. Sci. Rev. 169, 263–277 (2017).

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