Clim. Past Discuss.,
https://doi.org/10.5194/cp-2017-107-RC2, 2017

Climate of the Past Discussions

Interactive comment on "Drought and vegetation change in the central Rocky Mountains: Potential climatic mechanisms associated with the mega drought at 4200 cal yr BP" *by* Vachel A. Carter and Jacqueline Shinker

Anonymous Referee #2

Received and published: 21 December 2017

General Comments (Overall quality)

This study presents composite anomaly maps derived from the NARR dataset centered on the Upper Platte River Basin for five drought years since 1994. The maps present precipitation rate, temperature, 500 mb geopotential heights and vertical velocity, and 850 mb relative humidity. They indicate anomalously high geopotential heights during the growing seasons of the five drought years, which led to suppressed moisture transport to the region. The climatology methods are sound, results and interpretations are consistent with the data, which support their conclusions regarding the climatic

mechanisms for drought. The paper is generally well written. The results are not unexpected, and as such they are also not particularly novel. However, they do provide sound mechanistic understanding for what the atmosphere does to cause dry weather in this particular region.

The weaknesses of the study largely reside in the sparse explanation of the linkages with a so-called 'mega drought' during the mid-Holocene, for which there is less consensus than the authors convey, both in its spatial homogeneity and temporal expression. Changes are needed for these aspects of the paper, mostly in the form of additional explanation (and citations), more explicit acknowledgment of limitations, adjustments of tone, all to provide the missing information and provide a more informative discussion. Revisions are needed to provide a more accurate description of the paleohydroclimate of the region, and better inform readers about the utility and limitations of modern analogue methods as a diagnostic tool of paleoclimatic data. With these changes, the study will be more accurate and more likely to make a useful contribution.

Specific Comments (individual questions/issues)

1. Incomplete discussion of the regional extent of a so-called '∼150 year long' '4200 Cal BP mega drought' and implications for the utility of seasonal synoptic analogues.

More close attention to precisely what regions this study is meant to be useful for is needed. The Long Lake record, within the Medicine Bow Range, is described here as reflecting the Rocky Mountain region, according to another recently published paper by this author; Carter et al. (2017). However, the citation for the 4.2 ka 'mega' drought is Booth et al. (2005), who focus on the Northern Great Plains. It is not mentioned here that Booth et al.'s hypothesis was not further verified by additional high resolution multi-proxy data (e.g., Grimm et al., 2011). The other records mentioned in support of the drought are Wyoming dune activity and speleothem isotopes from northeastern Utah. However, the dune data is not well-enough dated (OSL and 14C) and conflicting interpretations are possible for the carbon and oxygen speleothem isotopes from

Minnetonka Cave.

Therefore, it is puzzling why the synoptic analyses are focused on the central Rocky mountain region of Wyoming (rather than the Northern Great Plains), and that there is no mention of other paleohydroclimatic data from Wyoming and northern Colorado that are numerous and nearby. Perhaps these regional selections were discussed and justified by Carter et al. (2017) but then this would need to be explained in more detail here. As it is, readers of this study cannot actually evaluate the spatial regional patterns of the modern analogues in relation to any proxy data because it is not shown on the maps. Unfortunately, there are nearby records that do not indicate a 4.2 ka 'mega' drought and which are not mentioned in this study. Through this omission, the study overlooks important implications that likely limit the utility of the modern analogue approach.

2. Incomplete discussion of the temporal uncertainty of drought timing and length and how to understand the relationship between seasonal analogues and lower frequency climate mean states (i.e., multi-decadal to century time-scales).

There is currently no helpful discussion of time-scales in the paper. The range of uncertainty associated with timing of the so called '$\sim$150 year' 'mega drought at 4200 Cal BP' is necessary to know in order to contemplate how seasonal anomalies could be translated by radiocarbon dated proxy records. At the very least some discussion of the age control, and uncertainties, for the timing of the quaking aspen rise at Long Lake is needed. The analogues provide seasonal-scale drought mechanisms but discussion about how seasonal synoptic scale mechanisms inform our understanding of drought mechanisms on century time-scales is not here.

3. Incomplete discussion of changing boundary conditions across the 5000 to 4000 Cal BP time window and the potential role of the North American Monsoon (NAM) and El Nino Southern Oscillation (ENSO) that could have potentially affected this study region during that time.

There is no discussion of previous studies based on nearby proxy records that indicate potentially significant changes in the mean state of the NAM and ENSO before and after $\sim$4 to 3 ka (see Reference list below). Modern day ENSO effects are discounted based on an argument that the region is currently unaffected. The same assumption for the mid-Holocene is likely incorrect. Even if a thorough evaluation of Holocene changes in mean state of NAM and ENSO is beyond the scope of this study, a discussion explaining their potential significance still needs to acknowledged. Changing boundary conditions present major challenges for understanding how to apply modern analogues and should be acknowledged.

4. Sampling of missing relevant references, and references therein: (in no particular order and by no means complete)

-Grimm E.C., Donovan, J.J., Brown, K.J., 2011. A high resolution record of climate variability and landscape response from Kettle Lake, northern Great Plains, North America. QSR 30, 2626-2650.

-Liu, Z. et al. 2014. Paired oxygen isotope records reveal modern North American atmospheric dynamics during the Holocene. Nature Communications 5:3701, doi:10.1038/ncomms4701.

-Higuera, P.E., Briles, C.E., Whitlock, C., 2014. Fire regime complacency and sensitivity to centennial- through millennial-scale climate change in Rocky Mountain subalpine forests, Colorado, USA. Journal of Ecology 102, 1429-1441.

-Anderson, L., Brunelle, A., Thompson, R.S., 2015. A multi-proxy record of hydroclimate, vegetation, fire and post-settlement impacts for a subalpine plateau, central Rocky Mountains, U.S.A. The Holocene 25, 932-943.

-Anderson, L. 2012. Rocky Mountain hydroclimate: Holocene variability and the role of insolation, ENSO, and the North American Monsoon. Global and Planetary Change 92-93, 198-208.

-Whitlock et al., 2012. Holocene seasonal variability inferred from multiple proxy records from Crevice Lake, Yellowstone National Park, USA. P3 331-332, 90-103

-Shuman, B.N., Marsicek, J., 2016. The structure of Holocene climate change in mid-latitude North America. QSR 141, 38-51.

Technical Corrections (typing errors, grammar etc.)

-As previous reviewer suggested, avoid emotive language and delete “Unfortunately” on lines 5 and 13. -p.5 Line 24, spelling of “analyse” -p.9 Line 24, “of flow of cold”?

Interactive comment on Clim. Past Discuss., https://doi.org/10.5194/cp-2017-107, 2017.