Clim. Past Discuss.,
https://doi.org/10.5194/cp-2019-22-RC1, 2019
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Climate of the Past
Discussions

Interactive comment on "Two types of North American droughts related to different atmospheric circulation patterns" *by* Angela-Maria Burgdorf et al.

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Received and published: 21 April 2019

I find this to be an interesting paper and the conclusions can largely be supported by the work presented.

My only major concern is with the discussion of the links to the AMO. The AMO is generally associated with a center of action in the North Atlantic subpolar gyre (e.g., O'Reilly et al. 2016, Wills et al. 2019, and references therein), which shows no clear anomaly in either of the presented composites. To the extent that the Atlantic temperature anomalies are there at all, they (Fig. 4c) look more like NAO-coupled variability of the ocean gyre circulation (i.e., warming in the Gulf Stream and GIN seas, but cooling

in between; Curry and McCartney 2001, Eden and Jung 2001, Sun et al. 2015, Wills et al. 2019). Since these anomalies are weak anyway, I would limit your discussion of connections to the AMO, instead saying something like "there appear to be differences in Atlantic temperatures between the two drought types, and that this could be related to modes of Atlantic multi-decadal variability such as the AMO or the NAO-coupled variability of the gyre circulation, as discussed in the literature". Note that I've included a lot of Atlantic multidecadal variability literature here because of my own interest in that part of the story, and in case it is useful, but I don't actually think it is necessary to go into/reference all of it in this manuscript.

I have made a number of other scientific comments below that you should consider, and have pointed out some typos and wording problems. Overall this is a substantial contribution and the needed revisions are minor. Nice work.

Scientific questions/issues:

1. 17 droughts is a small number of degrees of freedom to be computing clusters from. Could you quantify what you mean by "most conclusive clustering result" or give some metric of how this clustering depends upon sampling? Furthermore, you then explain a principal component analysis based approach and this left me confused as to which method you were using. Are you using two separate methods to characterize the droughts? Do they get the same answer?

2. With regards to your methodology of "each drought period was first expressed relative to a reference period that comprised 5 years before and 5 years after the drought period", have you compared this to the simpler approach of using anomalies from the long-term mean? It seems that this would be a simple check and I would hope it doesn't make a huge difference.

3. Do you have an explanation why the SLP anomalies tend to be weaker / less significant than the GPH anomalies? Physically this would arise if the circulation anomalies were baroclinic (consistent with a shift of the subtropical jet in the longitude band of

Pacific/North America), but I am not sure the EKF400 reanalysis can be trusted to that great of a degree. Could it possible be reconstructing less of the SLP variance than it does the GPH variance? Are the differences in anomaly amplitude actually quantitatively different? It may be helpful to rescale the SLP colorbar and to consider my following comment.

4. Why do your GPH figures seem to have a mean over the plotted domain that is less than zero? This could be due to variability in the Southern Hemisphere that is not relevant here. Could you remove this so that the plots are easier to parse?

5. How is the 95% significance level computed for the figures? In particular, how are you computing the number of temporal degrees of freedom? It would be helpful to state this in the caption.

6. Please check that there are no major differences between a composite of SST and the T2M composite shown. No need to show it, but it would be good to check this and state whether there are any significant differences.

7. I don't fully agree with your interpretation of Fig. 4. There are not particularly stronger or more significant ocean T2M anomalies in the North Atlantic than the North Pacific. Given the larger influence of tropical SST anomalies on the atmospheric circulation (e.g., Kushnir et al. 2001), the different atmospheric anomalies are just as likely to result from the tropical Pacific or tropical Atlantic temperature anomalies, even though those anomalies are smaller and not significant. You state multiple times in the discussion that the warmer North Atlantic (while not significant) could explain this or that atmospheric change, but I don't think these results make a strong case for that, especially not for any role of the AMO, which should have larger-scale coherent warm anomalies focused in the subpolar gyre (such as those seen in Fig. 5). It may be helpful to consider Ruprich-Robert et al. 2017, which looks at the differing impacts between the tropical and extratropical component of "AMO" anomalies in a climate model.

8. Could you extend the latitude range of your T2M plot over the equator? Any SST

anomalies in the 0-20°S latitude range could still have a large impact on the atmospheric circulation in the Northern Hemisphere.

Technical corrections:

- Page 1, Line 14 typo: "show" should be "shows"

- Page 1, Line 16-17: positive and negative anomalies in what index?

- Page 2, Line 4-6: the words "most relevant" are not very precise, consider rephrasing

- Page 2, Line 11: Is "moisture interpretation" a vocabulary word I am not aware of, or is this simply a wording problem where you should have said "are mostly restricted to interpretations as temperature and moisture"?

- Page 2, Line 13: typo, extraneous "of" after behind

- Consider referencing Enfield et al. 2001 as well for the Atlantic SST influence on multi-decadal drought

- Page 3, Line 18 typo: "or" instead of "of"

- Your abstract had me wondering why only summer SST/SLP/GPH is relevant. If you say you are looking at summer drought, then it would become clear why, and you then don't even need to say that it is summer SST/SLP/GPH.

- Page 4, Line 6: please state how/why the ensemble members differ

- Page 4, Line 25-25: I think "opposed to decadal variability" is not the correct word choice for what you are saying. Should be "compared to decadal variability" instead.

- Page 6, Line 8: missing word(s) between La Niña and El Niño

- Page 6, Line 9/10: twice you say "three" where I think you mean "two"

- Page 6, Line 17 typo: "at in"

- Page 6, Line 17: former and latter are both singular, and you should use "exhibits" with them, not “exhibit”

- May not Mai

- Mid-19th not mit-19th

- Page 8, Lines 19-20: the second half of this sentence needs to be reworded, this word order (especially with contribute at the end) does not work in English

- Page 8, Line 27: “turn-of-the-century drought” not “turn of the century”

- First sentence of conclusions: please add that this is the first time this has been studied in a climate reconstruction, because there have of course been model-based studies

References:

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