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Discussions

Interactive comment on "Convective suppression before and during the United States Northern Great Plains Flash Drought of 2017" *by* Tobias Gerken et al.

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1 Response to Reviewer 1

1.1 General comments:

This is a nice paper that is a good fit for HESS. The authors demonstrate the importance of atmospheric humidity deficits just before the onset of the severe drought in the Northern Great Plains (NGP) of the United States during 2017. I do have a few suggestions that I believe will improve the analysis, and some minor comments to improve

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Discussion paper

the flow and readability of the document. I believe these are minor suggestions, and I recommend publication after these issues are addressed.

We thank the reviewer for their work and the supportive comments. Please find below answers and changes to the text made in response.

1. Much of the interpretation of the figures is discussed in the text by referring to the month, but the figures use DOY on the x-axis. This forces the reader to do unnecessary work. I recommend re-doing Figures 2, 4, 5, 6, S1, S2, S3, and S4 with the months clearly indicated on the x-axis.

Thank you for pointing this out. We have updated the figures as recommended.

2. Some of the analysis centers on the use of potential evaporation. Two papers by Milly and Dunne (Nature Climate Change 2016, Journal of the American Water Resources Association 2017) highlight the dangers and pitfalls of many empirical formulas for Ep. They show that the best method (particularly moving into the future) is the simplest: just 80% of net radiation. Given those results, I believe you should re-compute your Ep-based calculations. However, your discussion on page 8 about the impact of estimating Rn since there are no direct observations is still highly relevant, perhaps even more relevant. I do wonder how Figure 5 would change with better Ep estimates.

Thank you for the paper suggestions. As both Reviewer 1 and Reviewer 2 pointed out ET_p is highly dependent on the availability of energy (i.e. net radiation), which is commonly not available, especially over the long term. We do not have reliable net radiation measurements at all sites across the entire study period and estimating ET_p as a fraction of net radiation would be highly sensitive to the net radiation estimate. For this reason we decided that it is best to keep using the standard method by the FAO to estimate ET_p and added additional discussion to the paper: "The interpretation of ET_p effects and sensitivity to drought development should be made cognizant of the fact that R_n was estimated and thus subject to associated uncertainties. At the same time, recent work (Milly & Dunne, 2016; Milly & Dunne 2017) found Penman-Monteith

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based ET_p estimates to be overly sensitive in response to climate change. Based on the reported low cloud cover during the drought, it is likely that the impact of energy supply is underrepresented in the current work." Thank you for pointing out the recent papers by Milly & Dunne.

3. Figure 4 is a very nice figure! This figure really demonstrates how different the conditions at TFX are from the other stations. I would like to see more focus on the temporal relationship between the anomalous 2017 behavior shown in this plot and the period of peak climatological rainfall occurrence at each station, which can be deduced from Figure 2. BIS and GGW both show a lengthy run of atmospherically dry days (where the black line in Figure 4 exceeds climatological norms) prior to the onset of the rainiest period (the dramatic increase in the slope of the blue region in Figure 2). Thus, at these stations, drought onset begins and intensifies right away. At the other two stations, the climatologically rainiest time period gets underway prior to the intrusion of atmospherically controlled conditions indicated in June and July in Figure 3 and Figure 4, and the drought is not as severe (RAP) or begins much later (TFX). I think these differences between the stations should be brought forth more in this paper in order to more effectively make your point about the importance of convectively-unfavorable atmospheric conditions driving rapid drought onset.

We would like to thank the reviewer for their supportive comment. We agree with his suggestion that there are important differences between BIS, GGW, TFX, and RAP with respect to rapid drought intensification. Both BIS and GGW are part of the region with an early and strong drought onset, whereas TFX is only affected later and RAP is at the edge of the severe drought region. We have added additional discussion with respect to Figures 2 and 4 to further highlight this in the text. The first paragraph of the discussion contains: "Notably, this period of low convective likelihood coincided with the period of the vegetative growing season which is climatologically wettest (Fig.2). At the other stations in contrast, such conditions either occur much later (TFX) or are less severe (RAP) thus limiting rapid drought intensification and severity. This differing

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behavior further highlights the likely importance of convectively unfavorable conditions and atmospheric control for drought."

1.2 Minor comments and edits:

1. Page 1, Line 21: “late May 2017”: I think early June is more consistent with the Figure and Table.

The drought was first indicated in the May 30 USDM. We changed the text to "late May to early June".

2. Page 4, Line 3: You should explicitly mention the local time that is equivalent to 12 UTC.

Thank you. We added: "(corresponding to 5:00 MST)"

3. Page 4, Line 31, “at all four soundings”: I noted here that TFX is not drier than climatology until day 200. This is the first indication that behavior at TFX is really quite different than at the other stations.

Thank you for pointing this out. Please see our response to *General Comment 4* for further detail and changes to text.

4. Page 5, Line 8, “in May”: at stations BIS and GGW (not all four).

Thank you for this comment. We added an explicit reference to BIS and GGW to the sentence.

5. Page 5, Line 19: include “climatological” before 75th percentile.

Added, thank you.

6. Figure 3: I had to look at this figure for a long time to sort out which months were anomalous at each station. I think this was simply because the many blue months

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were hard to distinguish from each other and because the July symbols sometimes got hidden under the August symbols and lines. Perhaps you can change your color choices to make it easier to quickly read these plots.

Thank you for the comment. During preparation of the figure, we tried several different color schemes and generally found that finding 7 different colors that are easily distinguishable, while also avoiding red and green in the same map, is very difficult. Also we feel that using blue for March and reddish for August and September, gives a good contrast.

7. Page 8, line 1: "tall" should be "deep."

Thank you for pointing this out, we changed the passage.

8. Figure S1: I didn't find this figure particularly helpful. It seems to me that the form is largely dictated by the nature of the denominator since Psum starts at zero and can only increase. I think the figure can be removed

The reviewer is correct that the shape of the curves is determined by an increasing denominator. This is why the figure was placed in the supplement. The intention of Figure S1 is to give some estimate of climatological interannual variation for Figure 1 and we would like to retain the figure there for reference.

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