Interactive comment on "Identification of Droughts and Heat Waves in Germany with Regional Climate Networks" by Gerd Schädler and Marcus Breil

Anonymous Referee #2
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With the meteorological data over Germany, the authors investigated the ability of climate network to identify drought and heatwave events. Several network metrics were found to be sensitive to the occurrences of these extreme events. Many droughts and heatwaves correspond to the variations of atmosphere in regional scale rather than local scale. Climate network can inform the spatio-temporal evolution of the regional climate systems, which might be a promising tool for droughts and heatwaves. This work could provide useful reference for studying these extreme events with climate network. However, some necessary information is missing in the manuscript, and some details should be concerned. To better inform the potential readers, I would suggest a major revision. Please find my suggestions in the following.

Dear referee,
thank you for your time and your constructive comments.
In response to the suggestions and comments of the three referees, we have made major changes in the manuscript in addition to specific answers to your comments:

- we added a section „Sensitivity of the metrics to correlation thresholds"
- we rewrote the „Comparison of the RCN results with other extreme indices" section. The figures are replaced by tables comparing the RCN metrics for a range of correlation thresholds with EDI/EHI.
- We focus now on the edge density as the relevant metric

Please find our answers to your specific comments below (in blue).

Major comments:

1. During average years, the distribution of the node degrees is close to the Poisson distribution, characteristic of random networks, while for extreme years the distribution is more uniform and heavy tailed. This is interesting. But the manuscript only demonstrates two cases of 2013 and 2018 for drought in Fig. 4, and two cases of 2002 and 2003 for heatwave in Fig. 9. How about the degree distribution curves in other years? The authors did not mention this in the manuscript. Degree distribution is the essential metric for network approach, please present the degree distribution curves for other years in main text or supplementary text.
We show and discuss cumulative degree distributions for normal and extreme years in the sensitivity section. We must admit that there was some wishful thinking along „normal ~ Poisson, extreme ~ flat and heavy tailed" on our side which we could not substantiate. We therefore omitted these considerations, nice as they would have been.

2. The choice of the correlation threshold of the time series determines the entries of the adjacency matrix, and this is crucial for the statistical significance and performance of climate network. The authors said that they had conducted the sensitivity runs with respect to correlation threshold. But I would suggest the authors to present more detailed results about your sensitivity runs in the supplementary text.

For example, please use a certain extreme year to illustrate how the choice of correlation threshold influences the shape of the degree distribution curve, and the value of edge density. And please illustrate the similar results for a certain average year.
We did this in the new sensitivity section

3. On page 5, lines 1-4, the computation of connection criterion for precipitation data is unusual for climate network links. Please give the citation about this computation method if there is a referred preceding work. Or please give more explanations why use such computation method.
Our formulation was a bit unclear and long-winded there, the correlation coefficient was used. We rephrased the sentences.

4. On page 16, lines 10, the authors declared that all metrics increase significantly during extreme events, and probability distributions change considerably. However, there is no significant test mentioned in the manuscript. Please present the statistical significance test (such as red noise test) in the main text or supplementary text, to support your conclusions.
We expanded on this and included a Wilcoxon test normal vs. extreme years in the sensitivity section.

5. On page 16, line 3-6, the authors said that 8 of 11 historical summertime heat events can be identified by RCNs. This was identified by the three metrics: edge density, p90 and clustering coefficient. How about the degree distribution? If plotting the degree distribution curves for the 3 missed events, and the 5 false-alarmed events, will they be close to Poisson distribution or uniform distribution? Please give more information and discussion about this.
We compare degree distributions in the sensitivity section. As we said in our response to your point 1 above, we could not substantiate the Poisson argument, and the attribution of distributions is unfortunately not as clear cut as we had assumed (see section on sensitivity in the revised paper).

Minor comments:

1. Please replace the word “resp.” with “and” throughout the manuscript, such as on page 1, line 3.
Done
2. On page 3, line 13, the authors defined the dry days as daily precipitation sums less than 1mm/day. Please explain the reason of selecting “1mm/day”, or give the citation of preceding works using this definition.
We use the E-Obs-definition of dry days described in: EUMETNET/ECSN optional programme: ’European Climate Assessment & Dataset (ECA&D)’
Algorithm Theoretical Basis Document (ATBD), or see
https://www.ecad.eu/FAQ/index.php#5
3. On page 4, line 12-14, on. The authors mentioned that, during extreme periods, large scale synchronous behaviour will prevail. For better informing the readers, please give citations that revealed that extreme events can make the synchronous behavior in climate system. The following reference might be helpful.
We are not shure if we understand your comment. In our context, extremes are characterised by the appearance of high temperatures or no precipitation in a region over an extended period of time. This is what we mean by „synchronous behaviour“.

4. In Fig. 1, please give the meaning of the background grey image.
Done (relief of Germany)
5. In Fig. 2, the image and its curves are blurry, please improve the quality of the image.
We omitted this figure in the revised manuscript.
6. In Fig. 3, the labels of horizontal axis are unclear. What are the meanings of "edgdens" and "cpp"? They might be edge density and clustering coefficient. These figure labels are not standardized. Please improve them, including the Figs. 6, 7 and 8.
These figures are replaced by tables in the revised manuscript.
7. In Figs. 4 and 9, please give clear indication of the red and blue curves. Moreover, the label of horizontal axis can be "Network degree", the label of vertical axis can be "Probability distribution function". Please improve them.
These figures do not appear any more in the revised manuscript. Blue was the RCN degree distribution, red the corresponding Poisson distribution.
8. In Figs. 3, 6, 7 and 8, please give the significance level for the correlation, such as the p-value.
In the revised manuscript, we provide tables for comparison.
9. Although most of extreme events can be identified by RCNs in this work, the used Pearson correlation is not the only method to construct climate network. Such as timelagged Pearson correlation, event synchronization method, mutual information method and causality method, they can be also used to compute the link strength between two network nodes (see the following references). In the summary part, please mention these methods, and please discuss why you selected the Pearson correlation. Or at least mention that these unused methods might be helpful to improve the performance of RCNs on studying heatwaves and droughts.
Donges, J.F., Petrova, I., Loew, A. et al. How complex climate networks complement eigen techniques for the statistical analysis of climatological data. Climate Dynamics, 45, 2407–2424 (2015).
Wang, Y., Gozolchiani, A., Ashkenazy, Y. , Berezin, Y. , Guez, O. , Havlin, S. The dominant imprint of rossby waves in the climate network. Physical Review Letters, 111(13):138501 (2013).
Odenweller, A. , Donner, R. V. Disentangling synchrony from serial dependency in paired-event time series. Physical Review E, 101(5) (2020).
Runge, J. , Petoukhov, V. , Donges, J. F. , Hlinka, J. , Jajcay, N. , Vejmelka, M. , et al. Identifying causal gateways and mediators in complex spatio-temporal systems. Nature Communications, 6, 8502 (2015).
Thank you for drawing our attention to these papers. We mentioned these methods in sec 2.1 and the summary of the revised manuscript and will use some of them in an upcoming study.

Interactive comment on Nonlin. Processes Geophys. Discuss., https://doi.org/10.5194/npg-2020-46, 2020.