Response to RC1:

S. Sippel et al., 2016

This manuscript highlights two concerns with the recent analysis presented in Donat et al (2016), who reported increasing trends in extreme precipitation and total precipitation in dry regions around the world. The two concerns raised by the authors with the analysis of Donat et al (2016) are valid. Here the authors present a re-analysis of the Donat et al (2016) work using more appropriate methodologies and find the results of Donat et al (2016) are highly dependent on the methodology they adopted, which has significant implications for the conclusions of Donat et al (2016). Overall, this manuscript presents an important critique of Donat et al (2016), which is highly relevant to the general scientific community. I believe the manuscript will be worthy of publication following moderate revision to improve the clarity of the manuscript, as it is hard to follow at times.

We thank the reviewer for the positive evaluation of our manuscript. We have taken the reviewer's suggestion about improving the clarity of the manuscript into account as specified below in detail.

My key comments / suggestions are as follows.

The overall style of this manuscript is abbreviated and densely packed. In fact, some sections are difficult to follow as helpful explanations are not provided. Figures and Tables are cited, but little accompanying explanation is provided to help the reader understand and interpret them. The current manuscript style is like a very compact ‘communication arising’. I think this style provides the key messages, but it is very difficult to follow the technical argument in places. Also, why are Appendix A and B not just normal Figures and Tables, like the other Figures and Tables? Why the separate Appendices? I recommend you move this material from the Appendices into the paper.

The key points made in this manuscript are fine, but the explanation accompanying the Figures and Tables requires expansion to improve the readability of the manuscript. At times I found it difficult to know how each Figure and Table slotted into the overall story; not because the material is irrelevant, but because a context for the material was not provided. There is a lot of interesting material in the Figures and Tables, which is hardly covered in the text. Expanding the explanations around the Figures and Tables will guide the reader through this important material and significantly increase the accessibility of this research.

We understand the reviewer's concerns about the very dense style of writing and presentation. Indeed, the reviewer is correct that our objective was to provide the key messages in a very dense format. To account for the issue rightly pointed out by the Reviewer and to improve readability and clarity, we extend the explanations in the revised manuscript, and improve the embedding and context of figures and tables. We will also move the tables into the main manuscript and provide the respective context.

For example, we extend the explanation of the normalization-induced bias (p. 3, l.1-14) by the following paragraph that provides more context to Fig. 1:

"This issue is illustrated in Fig. 1 for an artificial dataset that consists of n = 104 time series (e.g., 'grid cells') that are drawn randomly and independently from a Generalized Extreme Value distribution (GEV, Coles et al., 2001). The GEV distribution provides an asymptotical limit model for maxima derived from a sequence of random variables with fixed block size (Coles et al., 2001, e.g. the annual-maximum daily precipitation,), and is therefore appropriate to illustrate this issue. Normalising each time series in the artificial dataset with its mean in the first period yields a spatial 'reference period distribution' that is different from the spatial 'out-of-base period distribution' (and from the original GEV distribution, Fig. 1a), e.g. resulting in increased spatial averages in the out-of-base period (Fig. 1b). Furthermore, the normalisation procedure induces a considerable increase in the variance, skewness and higher statistical moments in the spatial distribution in the second period (see e.g. Fig. 1a), which would be of relevance if higher statistical moments (changes in spatial variance, etc.) would be studied. The reason for this observed difference lies in the fact that the sample mean (derived from the reference period) is a dependent estimator for the reference period time series, but a (virtually) independent estimator for the time period that lies outside of the reference period (Zhang et al., 2005; Sippel et al., 2015)."

Please note that in addition we include an analytical argument to derive an approximation for the expectation value of the normalization-induced bias in the revised version of the manuscript (please see attached pdf-file). However, in order to not compromise readability, we will include this in an Appendix or as Supplement. This argument thus provides an explanation as to why the biases are systematically positive outside of the reference period, and shows that this bias is proportional to the ratio between mean and standard deviation. We believe this is useful, because this type of reference period normalization is indeed common in many studies (not only in Donat et al.), and therefore the analytical approximation might provide a useful -first order- estimate on the magnitude of the expected bias.

Furthermore, to improve readability, we include an additional simple example that illustrates the second statistical issue, i.e. the "regression to the mean" effect, because the explanation as it stands now (p.3, l. 14-l.19) might not be immediately clear to all readers. Hence, we will add a simple example after l. 17:

"To illustrate this issue, recall the conceptual two-region example quoted above, where variation between the two available time periods would be entirely due to random causes. If any of the two periods would be chosen to stratify the dataset in one dry and one wet region, this would result in opposing changes (i.e. dry gets wetter, wet gets drier) in the second period."

Minor comments

Page 3, line 18: “the dataset will result”. Are you 100% certain it will result in a higher probability for wetter (drier) conditions. Or is a better word to use here “may” result. I think this paragraph would benefit from an expanded explanation of the statistical bias being discussed as it is not easy to follow.

Thanks for the comment, we agree the paragraph needs to be expanded to be made more clear. In a statistical sense (i.e. assume all grid cells to be random variables and assume many of them) we are certain that "selecting from the dry (wet) end of the spatial distribution in one subset of the dataset will result in a higher probability for wetter (drier) conditions in the remaining years". This is because random variation in the reference period plays a role and will lead to the regression to the mean phenomenon. But of course this only holds if there is not a systematic (global) shift outside the reference period. We will rephrase the sentence in a revised manuscript to make clear that it is a statistical expectation, rather than 100% certain.

Appendix B second Table: Replace “Rx1day” with “PRCPTOT” in the wet and dry regions.

Thanks for reading thoroughly. Correct, and has been changed.

Figure 1: you need to improve the explanation of this Figure. The illustration provided in the text (page 3, lines 6-13) was excellent, but the connection to Figure 1 was not obvious.

Again, thanks for pointing this out. As noted above, we have included an extended explanation for the figure (which will be inserted in p.3, l. 13)

Figure 3c, 3d: are the p-values for the one-sided and two-sided trend tests reported correct or have they been switched?

Again, thanks for reading thoroughly. The p-values have been switched indeed and we have corrected it.

Tables 1 & 2: Explain what Period Inc. means.

"Period Increment" means the period changes between the first

(1951-1980) and the second (1981-2010) period. We will explain this better in the revised manuscript.