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Monitoring and quantifying future climate projections of dryness and wetness extremes: SPI bias

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Reply to referee 1

We thank the referee for the valuable comments on our manuscript and the suggestions which help to improve the manuscript.

Introduction (general comment). The link between precipitation distribution and SPI calculation is given on page 10637 line 14: ”... For the SPI calculation the probability distribution of precipitation is of relevance. ...” and the subsequent discussion. The authors prefer to keep further details in the methods section.

Page 10637, line 5. Thank you, we include: ”Contrary to other precipitation based indices, like precipitation deciles (Gibbs and Maher (1967)) or the rainfall anomaly index (Rooy (1965), the SPI benefits from its unique description in different seasons or climate regions.”

Page 10638, line 11. This has to be changed to: ”... overestimation respectively underestimation of extreme dryness or wetness ...”

Section 3 (general comment). The authors impression was that the approach, of calculating the SPI transformation separetely for each month, could be regarded as a quasi standard due to the large amount of published material using the same procedure. This seems not generally be accepted. There are however, several reasons for prefering a seperate calculation in context of the presented manuscript.

First of all, it ensures the comparability with other analysis (Edwards and McKee (1997); Guttman (1999); Lloyd-Hughes and Saunders (2002); Bordi and Sutera (2001)), which also include partly a comparision of distribution functions. From a statistical point of view, estimating the yearly distribution violates the independence assumption, because of the pronounced seasonal cycle present in most regions worldwide. In addition, it is questionable whether monthly precipitation can be regarded as identical distributed or even unimodal on yearly basis. These problems are reduced and partly avoided by estimating the distribution separately for each month.

Applying the SPI calculation separetely for each month leads to consistent interpretations of the SPI values. That is, the resulting SPI classification is consistent, in terms of probability and SPI value, in different climate regimes and different seasons. The consequence is that the same precipitation amount will be classified differently in differing seasons. This however, is a plausible interpretation, because a drought condition in a rainy season shows other characteristics (precipitation amounts) than in a dry season.

In our opinion, these are the main reasons for calculating the SPI for each calendar month separately. An additional benefit is achieved by improving the accuracy or, in other words, reducing the bias due to the enlarged number of estimated parameters. One disadvantage comes along with this procedure, the uncertainty increases associated with each estimated parameter. This trade-off between bias and variance is discussed in the context of the Multi-Distribution SPI.

We include in section 2.1, page 10639, line 16: The SPI calculation is applied separately for each month. This procedure ensures seasonal independence, contrary to a yearly distribution estimation and leads to a consistent SPI classification not only in different climate regimes but also in differing seasons. The following steps are required (Fig. 1; according to McKee et al. (1993) and Edwards and McKee (1997), see also Bordi and Sutera (2001)):

Page 10646, line 17-18 and page 10649. The formulation is misleading. We wrote "... For the ease of interpretation the GD is at first compared to every other distribution separately, ..." (page 10646, lines 17-18). The one to one comparison is not only for readability but necessary in the given context. We agree that, in general, the overall comparisons (Figures 7 and 10) would suffice. This is hampered here due to similarity of the distribution functions and the circumstance that they are partely nested.

One main finding is, that there are at least three distributions (WD, EWD and GGD) outperforming the GD, independent of the choosen data set. Figures 6 and 9 highlight the problem with the GD assumption and show plausible alternatives. Additionally, these figures guide a direct interpretation of the SPI differences (Figure 8 and 11), which would not be possible with the overall comparisons alone. Furthermore, some conclusions are only possible by comparing the one to one comparison and the overall comparison. For example, the EWD and their strongly reduced AICD frequencies for small AICD (Figure 7a compared to Figure 6d) can be associated to the included WD and therefore are a result from nested type distribution functions. The intention of Figures 7 and 10 is to investigate, if one distribution is outperforming all others. However, no unique answer can be deduced for all data sets analysed, least for the CRU data set.

For these reasons the authors prefer to keep Figures 6 and 9 included, but will change the introductory part for the one to one comparison (p10646, l17-18) to a less misleading formulation. In consideration of the proposed additonal figures the authors belief is, that the presented material is enough to demonstrate the problem with the GD for the SPI calculation. However, they specify points more clearly which are only mentioned shortely in the text. Our suggestion is to present the following figures as supplementary material: Figure S1, overall comparison for EU, CRU data set with the GGD included and Figure S2, overall comparison for EU, synthetic data set based on CRU estimates (see also reply to page 10649).

Page 10646, line 23-27. Yes, this will be changed to: "Beginning with the reference data set, the GD (black dashed lines) gives most frequently the AIC best model in comparison with all alternatives (WD, BD, EWD and GGD; Fig. 6, red dashed lines).” Further, we will include the color coding for the dashed lines in the legends of Figure 6 and 9.

Page 10649. We refer to our reply to the comment on page 10646, line 17-18 and suggest to present the following figures as supplementary material: Figure S3, overall comparison for EU, EH5 data set with the GGD included and Figure S4, overall comparison for EU, synthetic data set based on EH5 estimates.

Page 10650, line 11. The increase holds for the one to one comparison for each of the alternative distributions. As a consequence this holds also for the overall comparison. This should be included. We will include the overall comparison figures for CRU and ECHAM5 data sets in section 3.4.

Page 10650, line 21. We will refer to the discussion in the appendix at this point.

Figures 12 and 13. We refer to our reply to the comment on page 10650, line 11

Page 10643, line 4. We change this.

Page 10651, line 21. The lower bound is higher than -2 and depends on the probability of zero precipitation (Wu et al. (2007), our reply to the comment 4 from referee 2).

Figure 6 and 9. We change all dotted lines to dashed-dotted lines.

Figure 8. Thank you, I overlooked this during the typesetting process.

References

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