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Interactive comment on "Effects of different reference periods on drought index estimations for 1901–2014" *by* Myoung-Jin Um et al.

Anonymous Referee #2

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The authors use two global precipitation and temperature datasets to calculate the SPEI drought metric using various choices of the calibration period. By quantifying drought severity, duration and extent in maps and by aggregating SPEI values over four regions, conclusions are reached on 'best practice' in setting the calibration period. A very nice touch is that the authors have looked at specific record-dry years for the regions under consideration, and visualised the effects of the choice of calibration period on the drought estimate.

The SPEI, like many other drought metrics, is a standardised metric making its estimates for dry or wet conditions comparable over diverse climatological areas. The issue what calibration period to use, and the effects of not using the full-length of the period for which data is available as calibration, has been debated in the literature. This makes the study a very welcome contribution to the discussion.

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However, my view on the manuscript that is currently submitted is that it may raise more questions than answers. There are quite a few things unclear and difficult to believe. Some of the choices made are unlucky, like the regions over which the SPEI is averaged. Some of these analyses need to be looked at again. Nevertheless, the analysis of the very dry years in the final parts of the paper show that the authors are capable of making some fine analysis - it is just a pity that they fail to observed some of the interesting aspects of their results.

The two main concerns relate 1) to the quality and validity of figs. 6, 7 and 8. I have trouble understanding what they mean and (especially fig. 7) can't be correct. 2) The analysis of figs. 9, 10, 11, 12, which touches at the essence of what the authors aim to investigate, is incomplete.

There are many other less serious concerns.

Main concerns

1. (a) fig. 6: I simply do not understand the quantity that is on the y-axis. The text (page 5, line 9-11) says: "the drought frequency as the ratio between the total number of drought events (...) relative to the total effective grid points." Are you calculating the number of grid points with SPEI12 $\leq$ -1, and then divide this number by the total number of grid points? Fig. 6 gives me ratios well above 1, so this can't be the case. There is also 'duration' on the x-axis. This is not the length of the time window over which the SPEI is calculated, is it? It seems to be the period for which a grid point stays at or below the SPEI12=-1 threshold, right?

   (b) Also fig. 7. This can't be true.There is a continuous upward line for Europe (and less so for the US) from 1901-1957 to 1958-2014. This would mean that in 1901 the moving average of SPEI was lowest for the coming century. I do not see dry years in this series like 1921, 1976 or 2003. All lines (for each period and region) have upward slopes. I think why this is (it is because

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of the use of Thornthwaite) but this is not discussed anywhere. It is strange that fig. 7 has upward trends for EU and US, while none of this is seen in fig. 4

(c) fig. 8 is not understandable. The x-axis says 'ascending order', claiming that for 'ascending order' $\sim$ 60 for CRU 1958-2014 and West Africa, 100% has SPEI $\leq$ -1. What does this mean?

2. The analysis of figs. 9-12 is a good idea, but there are a few things the authors need to explain and re-do.

(a) it is not clear which SPEI12 value is taken. For instance, the 2003 heat wave in Europe, which coincided with a dry period, the height of the heat wave was early August 2003. The Spring was rather dry and the heat wave stopped when Autumn was a bit wetter than usual for France and Spain and in December, northern Europe received more rain than usual.The question is now: which month provides the SPEI12 value which is characteristic of the 2003 drought in Europe? SPEI12 is based on 12-month accumulated precipitation, so do you take the December value (so that the whole of 2003 is captured)? Or do you take the annual averaged SPEI12, which then has a small influence of January 2002 as well in it..... A pragmatic approach is to make time series of monthly SPEI12 values and then take the month in 2003 with the lowest value, but over which area to average? The whole of Europe is nonsense, since the heatwave was much more local than that.

(b) All figures 9-12 show that for Ref3, the SPEI values are off the scale for some areas. I think that this is the main issue with the Ref3 approach. The SPEI (and SPI) are more-or-less normally distributed. By using the calibration from one period (like 1901-1957), you run the risk that the metric 'explodes' beyond the range in which the SPEI/SPI lives when droughts occur in the 1958-2014 period which are (much) more severe than anything seen in the

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calibration period. Essentially, using Ref3, you are not only assuming stationarity of the climate but also that the the whole probability distribution of droughts (and pluvials) is sampled in this period.

Other issues the authors may want to look into

1. The CRU dataset (and presumably the UDEL dataset as well) relax values to climatological values when data is insufficiently available. For Europe and North America, this will not be a big problem I think, but for West Africa and South Asia the number of records going back to 1901 are few and far in between. This means that the early period in these regions sees much less month-to-month variability as the more recent periods. Discuss the implications of this on your results.

2. The issue of the sensitivity has been raised earlier by Van der Schrier et al. 2013 (doi:10.1002-jgrd.50355) and Trenberth et al. 2014.

3. The Thornthwaite (1948) parameterization is directly related to temperature and has a huge trend. Even without a trend in precipitation amounts, the difference between the two will have a drying trend. This should be noted in the ms. and observed in the figures.

4. Sect. 2.2 It would be helpful for many readers what the descriptions are associated with the various SPI/SPEI values and the chance that 'severe' or 'extreme' drought is likely to occur. These are available in the McKee article or in: edo.jrc.ec.europa.eu - documents - factsheets - factsheet_spi.pdf

5. page 5, line 13-14. It is a good idea to see how large the region is with SPEI $\leq$ -1. However, simply counting grid squares does not work. You need to calculate area, where the grid areas are weighted with the cosine of the latitude.

6. page 6, lines 1-10. Interesting analysis, but the areas defined are more-or-less arbitrary. In Europe, for instance, there is a wetting trend in northern Europe and

a drying trend in southern Europe. It makes more sense to separate these two. Take a selection of the Giorgi regions: www.ipcc.ch - ipccreports - tar - wg1 - images - fig10-1.gif

7. page 6, Instead of calculating the trends in temperature, it makes more sense to calculate the Thornthwaite PET value. This makes this analysis directly comparable to the trends in precipitation.

8. fig. 2. Perhaps show the CRU climatology and the difference between UDEL and CRU? The pictures are very similar now.

9. fig. 4. What are we seeing? Is that the median, the 25th and 75th percentiles and min & max values? This is nowhere in the text or caption.

10. table 2. I see values of 26.1 degrees for area NA. This can't be North America (which is US in the text).

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