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Interactive comment on "GPCC Drought Index – a new, combined, and gridded global drought index" *by* M. Ziese et al.

M. Ziese et al.

markus.ziese@dwd.de

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Comment: The paper describes a combined drought index, the so called GPCC DI, an indicator computed as the average (where possible) of the Standardized Precipitation Index (in the slightly modified version used by the DWD, i.e. the SPI-DWD) and the Standardized Precipitation Evapotranspiration Index (SPEI). Such combined indicator is used by the GPCC center to provide the users with a quasi-real time global map of drought conditions. The global gridded data, at different time-steps and a spatial resolution of 1°x1° (Lon-Lat), can be freely downloaded at the official website of the GPCC. So, the paper presents an indicator that has been constructed for an online service, not for research purpose. In general, the paper is well-written and detailed with maps and tables that help the reader understand the methodology, the scope of

the paper, and the practical use of the combined indicator. However, there are a few major shortcomings that should be addressed to improve the paper. Otherwise (see the detailed review), one can find it somewhat too concise or hasty, in particular regarding sections 2, 3, and 6. Moreover, some key explanations of the methodology can puzzle an expert reader as it seems that they are not enough motivated. To be honest, I do not understand why the authors decided to combined two indicators (one of them based on PET), if they want to study precipitation anomalies, as stated in the text. Also, it seems that the authors aims at providing results without going too much in details about the statistical background of the indicators chosen. More citations are needed, in particular in the first sections of the paper. Finally, neither case studies nor comparisons with published literature are presented, thus the reader cannot be convinced that the methodology presented is effective. I suggest a major revision before the paper might be published. I suggest the authors going through my comments, without necessarily amending the manuscript following all of them, but spending more time to motivate their choices and decisions and adding more citations in first sections.

Detailed Review

P 243: Use capital letter after the - in the title. Abstract P244 L2: Are you sure that the GPCC-DI provides estimations of precipitation anomalies? If you combine two indicators, one of them is based on PET, the final result will not be dealing with precipitation anomalies only. P244 L8: Averaging? What do you mean? Do you mean that use averages (you should refer to accumulation periods, in drought studies it is far more common) of the input variables over the months and then you compute the drought indicators? 1. Introduction P244 L20-22: too simplistic. You should say more about drought definitions. For example, see Mishra and Singh (2010). P 245 L1: citation needed about the differences between aridity and drought. See, e.g., Wilhite (1993). 2. Some existing drought indices P 245 L20: there are a few global studies that need to be cited here. You should also cite the sc-PDSI, not only the PDSI, as it is currently more used than the PDSI. Some relevant studies are: Dai et al. (2004), Dai (2011,

2012, 2013), Sheffield et al. (2013), Trenberth et al. (2014). P 245 L24-25: Though the RDI is based on the ratio P/PET and on a log-normal distribution, there are some tricks that let you compute it when the PET is 0. For example, if you assign to PET the minimum values of values above 0 when it is 0, this may slightly bias the outputs, but it prevents you to "no values" when PET is 0 (cold climate). P 246 L2: Globally, the SPI has been recently applied by Spinoni et al. (2013), you should cite this study. P246 L8: In my opinion, you should also cite two other relevant publications regarding the SPEI, i.e. Vicente-Serrano et al. (2012) and Begueria et al. (2013). P246 L10: You should give now a few details about the measurement of PET. 3. Some existing drought index data sets and monitoring tools In general, I would put first the global datasets, then the continental, and then the regional ones. However this is my personal opinion and you do not have to change this Section. But avoid jargon (exclamation marks). 4. Used data P 248 L8: regular grid. You may provide the spatial resolution at this point. P 248 L 14-15: CAMS is more important - please motivate. P 248 L 18: say more about the re-gridding. 5. How to calculate the GPCC-DI P248 L23-25: You say you think that an interpolation of station data is more error-prone that the calculation of DI based on gridded data. Motivate this statement. In general, it is true, but it may also depends on the choice/ability of the interpolation procedure, the input variables used, the quality-check and the homogenization of records and so on. Sometimes, also the gridded databases suffer from gaps, outliers, and so on. P249 L9-10: looking at the figures, it seems that longer "averaging" periods correspond to more frequent normal conditions. Is this just happening for January 2014? It makes me wonder if you are averaging the DI values over six months. If this is true, it is a different procedure compared to drought indicators. Drought indicators for six months of accumulation periods are based on the cumulated P (or P-PET, etc.) over the previous six months, consequently the SPI-6 (or the SPEI-6) is standardized over the cumulated values of six months (for each month) and we should not see such "green maps" all over the world. I see that you want to show precipitation anomalies: this way, the averaging does make sense, but I don't get why you did not just compute precipitation anomalies instead of a combined drought

indicator. P 249 L11: If the evapotranspiration is really high and precipitation is normal, you might see drought conditions, so you should not say that droughts occur in areas where P is below normal, as you structured your indicator taking into account PET also. P 249 L16: fails? Physically, the Th's model says that PET=0 when mean temperature is near or below 0ËŽC, because when it happens the soil water layer is frozen and thus no evapotranspiration occurs. However, a small evapotranspiration still may occur, consequently some authors just assign 1mm to the lowest possible PET value. This way, you can compute the SPEI even when PET is very low. P249 L17: Which other parameterizations? You probably need to mention the Penman-Monteith's model (see e.g. Allen et al., 1998). Don't say that something else exists without naming it. P249 L24-25: see comment above. Moreover, you can simply shift the Gamma distribution to compute the SPEI when the PET is 0. Also, you can use the log-logistic distribution instead of the Gamma. There are many ways to overcome such problem. The fact that you do not compute the SPEI in cold regions may bias the outputs, because in such regions only precipitation drives the drought events in the GPCC-DI. P250 L6-7: comparable? Visually comparable? Provide statistical and spatial comparisons, not only comments. 5.1 How to calculate the parameters for the SPI-DWD and (the) SPEI P250 L 10: why 1961-990 and not 1971-2000 or 1981-2010? P250 L16: interval P250 L20-23: this sentence is puzzling. You should be more accurate when you describe statistical quantities. 6. How to calculate the GPCC-DI P251 L1: to be precise, this is not a standardized precipitation anomaly. Firstly, you are accounting for P and PET. Secondly, if, for a grid-point, one indicator is always available and the other one is not always available, you are averaging two indicators for some months and using just one of them for some other months: this way, the DI is not standardized anymore. P 251 L5: precipitation totals less than normal do not necessarily mean that drought is occurring. Written in this way, this sentence may be misleading. 7. Access to the GPCC-DI P 251 L15: Avoid jargon (exclamation mark) 8. Conclusions P252 L17-18: common sense. Drought can also occur in cold areas with "hostile" conditions (hostile: what for?). P252 L 21: data are not homogenized, this is a key point, you should not say in the last lines

of the paper. References P255 L1: year of publication is 2010.

Answer: Thanks for your comment. You suggest many, many additional citations. If we include all of these, then we end up with a review paper and a short data set description. But we want just to give the reader of short overview about the large efforts on drought monitoring to understand our motivation for the way we have gone. Since our target application is rather drought monitoring than drought research, we concentrated on the most widely used drought data sets and monitoring platforms instead of giving a full review about all the previous research papers . We cite some of the suggested literature, but not all.

The scope of the paper is to describe this drought index data set. For non-expert users, we wanted to introduce the meaning of a drought index as a deviation of defined normal conditions. Therefore, we used the phrase “precipitation anomaly” in the abstract. As you mentioned, if taken PET into account, it is not only a precipitation anomaly. Therefore, with redraft the abstract from “precipitation anomaly” to “water supply anomaly”, consistent to the introduction. We add a section with a case study and comparison of the GPCC-DI, SPEI and SPI from the European Drought Observatory for January, February and August 2003. Further, if we write about GPCC-DI calculated over several months, we redraft from “averaging” to “accumulation” or “aggregation”, as suggested, what is more precise.

Ad (1): We add some more definitions of drought and also a citation for the difference between drought and aridity.

Ad (2): The sc-PDSI was added to section 2: “The self-calibrated PDSI (sc-PDSI) was developed by Wells et al. (2004) to avoid the above mentioned empirical relationships. Nevertheless, the number of necessary input data was not reduced.” Most of the suggested additional literatures are studies regarding drought. But this paper is a data set description and no analysis of droughts itself, therefore we do not cite drought index based studies. Nevertheless, we add some more drought data sets to section 3. As the

calculation of the PET is discussed in section 5, we add there some more information. For details, see answer to remark 5.

Ad (3): We do not change the order from global to local. Since many monitoring activities refer to the local or regional scale, it might be useful to have the reverse order.

Ad (4): The spatial resolution of the GPCC First Guess Product was amended. The citation for the temperature dataset was repeated, because there it was written that the CAMS data set in more important in recent years. The formulation “regridding” is mistakable in this context. What we do is a reduction of the spatial resolution by means of an area and land portion weighting. We replaced the sentence “To match the GPCC grid the data are regridded to 1° spatial resolution taking land portion and area-average into account (see Fig. 2).” by “The resolution of the original CPC data is reduced by means of a land portion and area weighting to match the 1° GPCC grid. This leads to a slight smoothing of spatial temperature peaks (see Fig. 2).”.

Ad (5): As described in Becker et al. (2013), we use at least four input stations for each grid cell in our interpolations scheme. Therefore, outliers are efficiently smoothed. It happens that sometimes a station is missing, which was available the months before, or new stations can be used. But that would never concern all stations for a grid box due to the mentioned smoothing. We add no additional text to the article. One comment to the Full Data Reanalysis, as the mentioned before is for the First Guess Product. There are only stations with at least ten years of data applied. Therefore, the underlying station base is much more homogeneous than for the First Guess Product. As you mentioned the more “normal” conditions with increasing accumulation intervals, there are two points. First, we remove “averaging” in this context from the paper, because we aggregate the precipitation over the given number of months, as you wrote. Second, the precipitation anomalies alternating between drier and wetter than normal in the last months before January. This leads in many regions to a balancing of the anomalies and therefore the index is “normal”. Regarding droughts at high PET, we add a

comment, but at the SPEI description, not at the mentioned place in the comment: “whereas droughts also occur if PET is above normal and precipitation is roughly normal (at normal conditions of the SPI-DWD)”. We corrected the comment to computed PETs by means of Thornthwaites algorithm and added two sentences: “But also at temperatures below 0°C evapotranspiration take place. Some workarounds exits solving this problem by assuming arbitrary values for the PET like 1 mm/month or even lower values.” Additionally, we give the FAO Penman-Monteith equation as an alternative to Thornthwaites parameterization. We corrected, that we do not calculate the SPEI, if PET is set to zero.

Ad (5.1): We use the 1961 to 1990 reference period, because this is the currently official WMO reference period. This is now also stated in the article. It was changed from “averaging interval” to accumulation interval”. Here we cite now Lloyd-Hughes and Saunders (2002) and Wu et al. (2007), where the correct description is given.

Ad (6): We moved from “precipitation anomaly” to “anomaly of available water”, as you suggested above to take the effect of the PET into account. Also the effect of the PET is now added to the interpretation: “Negative values correspond with precipitation totals less than normal or precipitation roughly normal but PET highly above normal – drought - whereas positive values conform with precipitation totals wetter than normal and/or PET below normal.”

Ad (7): We redraft the second paragraph of this section: “The file for each month contains seven sets of GPCC-DI data for the different averaging intervals. These aggregation intervals are 1, 3, 6, 9, 12, 24 and 48 months. The GPCC-DI is provided at a regular, not projected global grid (-180° to 180° longitude and -90° to 90°latitude) with 1° latitude by longitude grid size. One zipped netCDF-file has about 235 KB.”

Ad (8): We replaced the phrase with the “hostile conditions” by “so in regions with tough environmental conditions”. We add a paragraph to section 8 describing the non-homogeneity of the input data and following restrictions of its applicability: “As the used

precipitation and temperature data are not homogenized, also the resulting GPCC-DI is not homogeneous. With its high timeliness it is designed for monitoring purposes, but owing to the non-homogeneous input data it is not applicable for climatological analyses (like studies related to trends in the occurrence of droughts).”

Thank you, we corrected the year of publication of Vicente-Serrano et al.

We replotted figures 1 and 2, now with the temperature scale in degree Celsius, as you suggest.

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