

## ***Interactive comment on “Little change in Palmer Drought Severity Index across global land under warming in climate projections” by Yuting Yang et al.***

### **Anonymous Referee #2**

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#### General Comments

This report is a welcome contribution to the ongoing discussion in the literature regarding how to characterize changes in drought incidence under the changing climate. The paper is a follow-up to the paper by Yang et al (2019), which presents an equation that generally captures the variation of effective stomatal resistance within CMIP5 models as a function of atmospheric carbon dioxide concentration. In this paper, that relation is used to show how a popular drought index—the PDSI—can be adapted to characterize drought in our world of greenhouse warming. A readily available and simple offline alternative to the usual PDSI (and, in particular, to the Allen et al. form of the

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Penman-Monteith equation) will likely be of value to climate-change impacts analysts, many of whom may not be familiar enough with the biological processes in play or have the resources to model the processes with greater fidelity. That being said, it is important to evaluate the performance of the modified index carefully and to lay out clearly the assumptions and limitations in one place.

To some extent, the literature in this area has had a certain feel of X-vs-Y to it, X being increase of drought, and Y being no change in drought to speak of. This paper moves a bit toward the middle in acknowledging increases in drought incidence, but the overall presentation still has the feel of Y. Some specific suggestions for movement toward what might be a more balanced presentation are offered below for the authors' consideration.

#### Specific Comments

The title “Little Change...” (which echoes that of Sheffield et al.) places the paper in the Y category mentioned in the General Comments above. To me, and perhaps to other readers, “little” implies something along the lines of “nothing to worry about.” The authors might consider modifying the title to avoid that implication.

The reference to “PDSI” in the title, without qualification, is potentially confusing. Other publications (as well as this one) have shown that the usual PDSI equation applied to climate-change projections do imply increased drought. Would it be appropriate to change “PDSI” to “Co2-aware PDSI” or something else that conveys that idea?

In general, the paper does a good job of citing the relevant literature. However, it's not clear to me that the abstract does justice to the previous literature (including the authors' own works) when it uses the phrase “resolve a paradox.”

It's not immediately apparent what it means for the abstract to say that “global PDSI\_CMIP5” remains generally unchanged. If this refers to the global average of the time average of the ensemble average of PDSI, then it is possible that the element

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of variability in space, in time, and across models could be lost in translation. It's hard to think about "drought" without considering variability.

The statement in the abstract that "projected increase in PDSI drought reported previously is primarily due to ignoring the vegetation response" seems somewhat overstated when I look at Figure 3, which suggests that the increase is about 50% or so due to ignoring the biological response, leaving another 50% that is not due to that.

I did not carefully evaluate what was implied by lines 138-140: "The PDSIs were calculated using outputs of each CMIP5 model in turn, and the ensemble PDSIs (averaging PDSIs over models) were used in the following analyses," but that passage gave me pause. Won't averaging across models reduce both the temporal and spatial variability and thereby impact drought estimates?

lines 208-210. The criterion for substantial increase in drought appears to be based on the change in the average value of PDSI rather than the change in the exceedance of a threshold. Is that a good measure?

lines 210-212. It was stated earlier that ensemble averages were used for the analysis. It's quite possible I've read through the paper too quickly; the authors might consider taking precautions to avoid letting the casual reader get confused.

lines 233-235. I am confused by "yet on the other hand" (which by the way sounds redundant in itself) combined with "also," since both effects are working in the same direction. The "also" seems out of place here. I get that "also" here was meant in the sense of "and here's another thing it does," but the current sentence structure doesn't work for me.

line 242-247. I think this is another place where the authors could relax away from the "Y" position mentioned in the general comments. It seems to me that the dryness near the surface might be important for wildfire risk and perhaps for various biological processes that take place close to the surface. This idea might even be allowed to

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bubble up into the abstract.

Figures 1 and 2. The creation of these figures to convey what's going on is appreciated. Figure 2 takes a while to understand. It might help if the four black arrows and the plus signs were removed. It also might help if there were another column for how  $E_p$  is computed.

Figure 3. A map of trend in PDSI doesn't seem as useful as a map of trend in exceedance of some substantial value of PDSI.

lines 435-436. "where the same sign of the PDSI trend is identified in at least 8 out of the 16 CMIP5 models." Taken alone, without additional explanation in the caption, it seems like this would be true everywhere.

Figure 4. This figure averages out a lot of information. Do the benefits of its inclusion outweigh the possible misunderstanding that it might generate? See also related comment above regarding "global PDSI\_CMIP5" in abstract.

Figure 5. As mentioned elsewhere, change in (expected value of) PDSI might not be the best metric for change in drought. Change in exceedance of thresholds might be better. I wouldn't be surprised if these were quite parallel, but to leave that taken for granted could weaken the overall impact of the paper.

#### Technical Corrections

line 93. Delete "and"

line 233. Change "increase" to "increases"

line 270-271. Consider changing "due to the ignorance of" to "due to ignoring."

line 285. Change semicolon to period.

line 433. Change "e-f" to "d-f"

line 287. Add period.

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