Hydrol. Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/hess-2019-701-RC1, 2020

Hydrology and Earth System Sciences Discussions
Open Access

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 #1

Received and published: 24 February 2020

General comments

This paper analyzes projected changes in PDSI. It compares PDSI estimates obtained using potential evapotranspiration with and without accounting for the response of vegetation to increasing atmospheric CO2 concentration, as well as a direct estimate based on hydrological output from CMIP5 climate models. The main point is that there is no significant global drying trend based on PDSI, and the reason this was previously suggested is that offline impact models did not account for the response of vegetation to increased CO2. As noted by the authors (page 3, lines 54–57), several recent studies have already pointed out this problem when computing ET offline.

Printer-friendly version

Discussion paper

The valid point the authors make of refuting a general rule of “warming leads to drying” should not be interpreted as there will be no drying. The authors could try to make this even clearer by further emphasizing the projected increase in land area fraction under extreme conditions of water availability as well as the uncertainties in the projections.

Overall, the manuscript is well-structured and clearly conveys its main point. Nonetheless, it would be useful to further discuss some aspects of the methodology and address potential caveats of the PDSI.

Specific comments

1. Although PDSI has been a widely used index, it is not exempt from caveats. When analyzing projected changes in drought (water availability) it would be beneficial to also directly show the changes in relevant variables like soil moisture and precipitation minus evapotranspiration. Although results for SPEI are presented in the supplement, a summary of trends in projected soil moisture anomalies would be a suitable complement to the manuscript. Particularly, maps of the trends would provide a more comprehensive picture as opposed to the global averages.

2. It appears that the climatically appropriate for existing conditions (CAFEC) coefficients are estimated for the entire period 1901–2100 (if this is the case, it should be explicitly stated). This seems counterintuitive to me when analyzing projected changes. Why would it not be more meaningful to estimate the soil moisture anomalies relative to some reference conditions from the past or present, e.g. 1901–1960 as for SPEI in Fig. S4?

3. It would be relevant to discuss and/or provide sensitivity tests to assumptions underlying the calculation of PDSI. For example, what value was selected for the available water capacity (AWC)? Is it constant in space? Are the values model dependent?

4. It would be insightful to know more about the variability of PDSI given that all data is already available. For example, maps of change in the standard deviation of PDSI

from a future period relative to present-day can be shown in the supplement.

5. The manuscript concludes (page 11, lines 273–274) highlighting the increased spatial variability in surface hydrological conditions. In this context, it could be appropriate to also discuss local changes in temporal variability, see Kumar et al. (2013).

Kumar, S., Lawrence, D. M., Dirmeyer, P. A. & Sheffield, J. Less reliable water availability in the 21st century climate projections. Earth's Futur. 2, 152–160 (2013).

6. Page 6, lines 129–132: Potential for discussion. Differences between total soil-depth representation in CMIP models may lead to systematic differences in PDSI estimates from individual models.

7. It should be noted that the discussed response of vegetation to increasing CO2 applies to transpiration, but not to evaporation from the soil and canopy as well as snow sublimation. In this case, increasing CO2 and temperature would have a direct effect towards increasing evaporation.

8. Fig. 3 shows that even for direct CMIP5 output there can be a considerable increase in the land fraction experiencing extreme drought/moist conditions. These areas could be even larger if we were to consider the full spread of the CMIP5 ensemble as opposed to plus/minus one standard deviation. Is it reasonable to consider that differences in how individual models represent the response of vegetation to increasing CO2 could explain the spread in CMIP5 projections? This may be an important discussion point for the paper.

9. What is the reason why this particular subset of 16 CMIP5 models was used and not all models that are available?

10. Trends in vegetation greening are mentioned in the abstract. The following reference about hidden vegetation browning could be helpful.

Pan, N., Feng, X., Fu, B., Wang, S., Ji, F. and Pan, S.: Increasing global vegetation browning hidden in overall vegetation greening: Insights from time-varying trends, Remote Sens. Environ., 214, 59–72, doi:10.1016/J.RSE.2018.05.018, 2018.

Technical comments

1. In Palmer (1965), equation 26 appears to use monthly recharge (R) instead of long-term average R. This might be worth double checking since it seemed to me the average is used in the provided scripts.

2. Lines 45 and 225: Inconsistency in the reference Lehner et al., 2017 or 2018? There is only one reference entry.

3. Page 10, lines 23: I would delete the word “also” since the effects are opposite.

4. Page 11, line 273: Is Fig. 3b–f correct? Or Fig. 3b–c?

5. Figure 3: The selection criteria for where to have the black dots does not seem optimal. As it is now, it is showing all regions where the mean and median of PDSI have the same sign. I would suggest a different threshold for model agreement, e.g. black dots where at least 2/3 of the models agree in sign. Alternatively, it could be useful to include in the supplement maps of model agreement that are complementary to Figs. 3d–f.

6. Page 8, line 194 and 196: It should be Fig. 4.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2019-701, 2020.