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Earth System Dynamics
Discussions

Interactive comment on "Global hydrological droughts in the 21st century under a changing hydrological regime" *by* N. Wanders et al.

Anonymous Referee #2

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General comments

This paper is well written, well-structured and easy to follow. It addresses a relevant scientific question and falls within the scope of the journal. The objective of the paper is to globally address the impact of climate change on future hydrological drought by using a transient derived threshold for drought. This objective divides the paper into two parts: (1) a global hydrological model is used and future hydrological droughts are simulated by applying a combination of five GCMs and four emission scenarios (RCPs). The results show an increased drought duration and drought deficit volume in discharge. The uncertainty ranges are shown and the results are compared to other studies. Although this is not necessarily innovative in itself, the value lies in the rather high amount of up-to-date GCM-RCP combinations that have been used. Thereafter,

(2) a transient method for defining the threshold for droughts is introduced and applied globally. By applying the new method where the threshold of drought changes over time, it is shown that simulated future droughts have a much shorter duration in comparison to when the non-transient conventional variable threshold (Van Loon and Van Lanen, 2012; Van Lanen et al., 2013) is applied. The authors discuss the differences in results, but the potential benefits of the proposed method remains somehow unclear. The authors suggest a dynamic definition of drought. Although this might be considered novel, it also raises an issue which is not discussed. With a definition of drought that changes over time, it will probably be more complicated to compare the magnitude of past, current and future drought events. To improve the paper I would therefore suggest discussing potential pitfalls when having a dynamic definition of drought. I would also like to see that the benefits of a dynamic drought definition are further elaborated upon.

Specific comments

- The manuscript shows how the drought duration and drought deficit volume is simulated to be greater for the non-transient approach in comparison to the dynamic, transient approach. This is valuable information since it shows how changes in the hydrological regime might influence the simulation of future drought duration. Nonetheless, I am not completely convinced by the transient approach and would suggest a clearer discussion in which way the transient approach is superior the non-transient. In my opinion the transient approach might also be slightly misleading. For example, decision makers might be interested in investing in hydropower. In order to understand how the runoff is about to change, they would probably want to compare the future situation in a direct relation to the current situation (non-transient analysis). In this example the transient approach would not allow a direct comparison between the time periods; instead it would underestimate the future drought duration. Hence, it would risk that the decision would be based on "false" information. With this in mind I would recommend elaborating on the potential weaknesses of the transient method.

- It is shown that different results are obtained with the transient and non-transient method. Still, I would like to see a clearer motivation why the transient method should be used. Furthermore, is the transient method suggested as “complete” or just applied in order to show that it is necessary to consider changes in the hydrological regime when addressing future droughts?

- Would it be advisable to apply the transient method also on other drought indices like the SPI, or when comparing current drought events with past ones?

- Page 658, line 14-18. How was it decided upon these thresholds for the robust decrease/increase etc.? Were they chosen arbitrary?

- Page 662, line 8-14. The VTMt results are presented before the VTM results. To facilitate the reading I would recommend presenting the methods the other way around throughout the paper. That means; first the more traditional non-transient method, thereafter what changed when you applied the new one. - Page 664, line 3-4. “. . ., which seems to be in line with their study.” Here a high drought frequency is compared with high deficit volumes (extreme low-flows) and it is concluded that the result seem to agree. This seems to disagree with page 663, line 13-15 where a study by Wanders and Van Lanen (2013) shows lower drought frequency and increase deficit volume. Please clarify. - Figure 1. Why is there such a fast drop in the transient threshold for the year 2075? I would expect it to be smoother if a running mean is used.

- Figure 4. The figure shows the area in drought for five major Koeppen-Geigner climatic regions. The manuscript suggests that the threshold for drought should be transient. To allow a more transparent comparison between the lines in figure 4 it would therefore be valuable to add a figure-line showing the changes in area of the Köppen-Geigner climate types under future climate. Alternatively, figure A1 could be extended. The changes could be derived based on a running mean of temperature and precipitation.

Technical corrections/suggestions

Page 651, line 6: “The 2011 drought in the Horn of Africa caused large famine across the region. . .”

Page 651, line 8: “Drought, heat waves and forest fires caused almost 80.000 deaths in Europe”, under which period, 1998-2009?

Page 651, line 11: some -> certain

Page 651, line 18: “precipitation and/or temperature, which also propagate to reduced soil moisture”

Page 652, line 1: “Furthermore, Forzieri et al. (2014a) only assesses future drought for one continent (i.e. Europe)”. It should be mentioned that the resolution is higher (ca. 25km).

Page 653, line 1: erase “used in this study”

Page 658, line 7: “130 years of observed and simulated discharge”

Page 658, line 13: “significant ($p < 0.05$) trends were taken. . .”

Page 661, line 7-8: do you mean Fig 3-4?

Page 661, line 10: “Precipitation totals for these regions show an increase of 30–100mm-1 year for the period 1971–2000 compared to 2070–2099. . .” Unclear, isn’t that a decrease in precipitation?

Page 661, line 10 and 24: use “annual precipitation” rather than mm year-1

Page 662, line 2: occurs

Page 662, line 17: remove “slightly”

Interactive comment on Earth Syst. Dynam. Discuss., 5, 649, 2014.