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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Using an integrated hydrological model to estimate the usefulness of meteorological drought indices in a changing climate" *by* Diane von Gunten et al.

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General comments:

The study evaluates the suitability of seven meteorological drought indicators for assessing hydrological drought in present and future climates for a semiarid catchment in Spain. To assess the link between meteorological and hydrological drought in the future the authors use different climate scenarios for calculating drought indicators and compare it to discharge, water deficit, and groundwater heads simulated with a hydrological model. In addition, the authors investigate differences in future drought intensity based on different drought indicators and different regional climate models. The study addresses an important topic and reveals new insights into drought propagation with

regard to future change. The authors present interesting findings and draw valuable conclusions about the suitability of drought indicators.

One specific aspect the authors highlight is that correlation analysis between meteorological drought indicators and hydrological variables (as conducted in many studies) may not always provide sufficient information since it captures the dynamics only. Further measures should be considered (e.g. models bias). What I find somewhat contradictory in this respect is the low temporal resolution in the applied correlation and regression analysis (and therefore averaged dynamics). The authors use annual hydrological variables. I think that for drought analysis and better understanding drought propagation in the future a sub-annual resolution (at least seasonal dis-aggregation) would be highly desirable. Put differently, how much can we infer from an annual average relation between meteorological drought and streamflow or groundwater levels in contrast to e.g. seasonal data, especially when thinking about water management and planning issues? A concern that is somewhat related is that very little information is provided about hydrological processes in the catchment (now and changes in the future) and how they relate to differences in the linkage to drought indicators. Is enhanced ET the only factor? I would appreciate to see time series of modeled precipitation, ET, future discharge, groundwater levels etc. for a more process-based picture of the link between a precipitation decrease/ET increase and hydrological drought. This may also help to understand how generalizable the findings from this unique catchment are .

Regarding the paper presentation, the paper is well written and clearly structured. However, the manuscript would benefit from shortening the methods section (suggestions see below). Although I appreciate the attempt to be very transparent, currently almost 9 pages present methods, and only 5 results and discussion, which seems a bit imbalanced.

Detailed comments and/or suggestions:

Abstract:

“We conclude that meteorological drought indices are able to identify the timing of hydrological impacts of droughts in present and future climate. “ I am bit concerned about the general inference on timing between the two variables looking at annual averages. What about e.g. “summer flash droughts” and intermittent heavy rainfall (likely leading to enhanced surface runoff and less recharge) versus a continuous seasonal dry period versus wetter period? Wouldn’t the annual average response be similar, but the dynamics between meteorological and hydrological drought and thus water availability and implications for management be different at shorter time scales?

Methods:

Since you provide an overview of the methods in section 2.1 some of the later information is a bit redundant and could be heavily shortened.

P 5, L 6-13: Is this needed in this detail?

Study area: since you provide a detailed description of the basin a link to changes in catchment processes in the future may be interesting to pick up in the results/discussion.

Climate scenarios: Could this be shortened and potentially merged with the results 3.1 section (since this section contains quite a bit of methodology in my view)?

Irrigation scenarios: Where does irrigation water come from? Surface water, groundwater abstractions, reservoirs, are there any water transfers?

Drought indictors: This section could be strongly condensed. Do you really need the introductory part (P8, L13-30)? P, L23-30: this could go into the discussion section. SPI/SPEI/PDSI are all frequently used. I therefore suggest making reference to existing papers and keeping these methods brief.

Computation of potential evapotranspiration: Could some of the details go into an ap-

pendix?

Methods of comparing the drought indices to predict hydrological variables: Which model are the future drought indicators based on for predicting the hydrological response (e.g. shown in Figure 7)? I assume it is average of the outputs of the four regional climate models as in Figure 6 bottom panel but this information should be given in this section. I would suggest presenting a relative bias rather than an absolute one. In the results you also set the absolute values into context (e.g. P9, L21: “the largest bias is equivalent to only 3.9% of the present water deficit”).

Results:

Section 3.1: see comment in methods section

Figure 3: There are seasonal differences, which is why I think information may be lost when only looking at annual averages for the correlation/regression analysis.

Section 3.2: P14, L13: “details are available in the supplementary material”: where do I find this?

Figure 5: Is the irrigation scenario a mean of PIRR and FUTIRR or just PIRR? I don’t fully agree that the correlation coefficients are all similar, as you write. How do you explain EDI < 0.5? I think if you decrease the panel size there would be enough space for including the correlation coefficients with water deficit and groundwater head. EDI performs especially poor when considering the ETHZ model – any ideas why?

Section 3.3: Generally I think this a very interesting approach and strong outcome. I consider figure 5-7 the core part of your results since this is where you address the link between meteorological indicators and hydrological variables in present and future climates. However, if you start out with three hydrological variables (including hydraulic heads) I would like to see this reflected in this section but currently there is no information about hydraulic heads in the presented material.

Figure 6, right panel: you write that “the relationship between SPEI and discharge is

relatively stable in different climates". I find it hard to distinguish the pink from the red dots but to me the slope of the pink or red dot relation looks higher than for the present regression line? Have you considered comparing/plotting regression coefficients for the different indicators and scenarios to go beyond this one SPEI example scatter plot?

Figure 7: see comment in methods on future drought indicators used for prediction: is this a multi-model average? Since you have different units for your hydrological variables and to better relate it to the present scenario I would prefer relative over absolute values for model bias. What about displaying model bias for groundwater head in Figure 7 in addition? What can you infer from the analysis of this variable?

Section 3.4: I am curious about the underlying drivers of the differences between models regarding drought intensity. It seems worthwhile to add some explanations into the discussion section.

General: To condense the results section you could omit a few sentences repeating/explaining methods or introducing figures since the figures are well readable (examples are: P14, L28-31; P15, L11-13).

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