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Discussions

Interactive comment on "Future shift of the relative roles of precipitation and temperature in controlling annual runoff in the conterminous United States" *by* Kai Duan et al.

Anonymous Referee #1

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Review of the manuscript "Future shift of the relative roles of precipitation and temperature in controlling annual runoff in the conterminous United States" by Duan et al.

In this manuscript, Duan et al. evaluated the relative importance of climate variables (precipitation, temperature, humidity, wind speed and solar radiation) in changing the annual runoff volume under future climate change scenarios in the United States. They apply an ecohydrological model on a monthly basis and additionally run the model with two different potential evaporation inputs. Temperature will outweight the historic importance of precipitation for runoff variability in the future in most of the U.S. although

increased humidity can partly reduce evaporative demand and therefore lead to an increase in runoff. The way potential evaporation is calculated has an effect on runoff simulations, but using a variety of climate variables is considered as a more important factor in climate studies.

This is an interesting study and I like the clear and well described concept. The results are illustrated and described in detail for different levels of spatial aggregations and clearly support the conclusions. The main limitations as well as the implications of the study are well discussed. To further improve the manuscript I have some suggestions listed below including the combination of some of the tables and figures to condense the information and evaluating the results based on hydroclimatic regions.

I hope that the comments below will be helpful for the authors to improve their manuscript.

Major comments:

P2 Abstract: I think the abstract would benefit from some more precise or detailed information. E.g. L3: name of the model and simulated time resolution (month); L13-16: It is stated that precipitation will lead to an increase in runoff, while for temperature it only states that there is a large effect but does not explicitly say in which direction (increase or decrease). L18-19: Why do the Midwest and South-Central regions have a severe runoff depletion?

P5 L16-18: This comment is about the WaSSi model: a) What are the benefits of using the WaSSI model and not a simpler model (e.g. a model with less input data and probably less parameters) in your study? b) Snow routine and the ET model are well described. Could you also give some more information about the structure of the SAC-SMA model? A schematic of the WaSSi model could help the reader to more easily understand the model structure, its disaggregation into land cover types, number of parameters, etc. c) Does each catchment (HUC 8 level) have only one single parameter set which is used for runoff simulations and why? Using many more parameter sets could make the results more robust and reliable.

P5 L16-18: Could you maybe say a few words about the selection criteria of your study catchments? E.g. did you use all catchments available in the U.S. at HUC 8 level and is human influence on the study catchments problematic for your results? Please also provide the source of your catchment data (catchment outline, runoff data, etc.) in the text and the references.

P8 L12-14: EInt is calculated as the difference between the change in runoff and the combined effect of the climate variables. Doesn't this assume a perfect model, i.e. that the selected variables can explain all the runoff changes?

P9 L4-6: This sentence lists minimum and maximum temperature as climate variables, but Fig. 3 refers to surface air temperature only. Does Fig. 3 show the mean of the minimum and the maximum temperature? Which temperature was used for runoff simulations?

P14 L20-22; P15 L9-11; P15 L19-22: I strongly recommend to make more explicit references to tables and figures to clearly indicate the reader where to find the described information. E.g. P14 L20-22: Table 2 does not provide information about Sh, Rs and Ws. P15 L9-11 and P15 L19-22: I couldn't find the indicated percentages in Fig. 8 or Table 3.

P19-P20 Conclusions: Similar to the abstract I would recommend to be more precise. E.g. L17: to what exactly do the large uncertainty and spatial variability refer to? (projected changes in runoff?). L1: what is negatively affected by the increasing temperature? (annual runoff?). L6-7: temperature will decrease runoff. L17: temperature based PET tends to be oversensitive to changes in temperature compared to Penman-Monteith.

P27 Table 1: Table 1 and Fig. 3 contain to a large degree redundant information. To me it is most important to have an impression of the general trends of the 5 climate variables T, P, Sh, Rs and Ws in the two RCPs while the origin country of a GCM is not relevant for the interpretation of the results. Since Fig. 3 provides the trend information of the climate variables, I recommend to delete Table 1 and list the names of the GCMs in the text of section 2.3.

P31 Fig. 1: I am not sure if these two figures are necessary. Fig. 1a is only used in the context of the WaSSi model, where the individual land cover types are listed. Since the map is not further used in the results or discussion part I probably would remove it. Fig. 1b could maybe also be skipped - WRR names could be added to Table 2 and WRR IDs could be added to the maps of Fig.5 and Fig.8. Having the IDs directly in the maps would support the readability of the results where usually a reference to the WRR is made.

P36 Fig. 6: This is a more general comment on the use of WRRs and therefore also applies to Table 2 and the corresponding results parts. I wonder how much the averaged results on the level of WRR actually tell us? WRR can be considered as very large watersheds spanning a wide range of land cover types and hydroclimates. The runoff response of subbasins of a WRR to changes in climate variables can therefore be very diverse, which can be seen in Fig. 8. From a hydrological perspective it would be interesting to see exactly these relationships between changes in runoff response and hydroclimate, land cover, etc. Averaging the runoff response over a WRR makes conclusions about possible relationships difficult. In my opinion it would be worth to analyze the runoff response to changes in P and T in dependence of the hydroclimate (e.g. see studies of Coopersmith et al., 2014; Sawicz et al., 2014) or the Köppen Geiger climate zones.

P38 Fig. 8: The information of Table 3 and Fig. 8 is very similar. Is it possible to combine the two? The fact that solar radiation, wind speed and specific humidity have little effect on changes in runoff response is already illustrated in Fig. 7 and therefore does not need to be repeated in Table 3. The areal proportions for precipitation and temperature as driving factors could be directly added to the maps in Fig. 8.

Minor comments:

P8 L3-16: The terms “climate variables” and “driving factors” are used interchangeably as synonyms, which can be confusing. I recommend to use only one of the two terms.

P8 L7-8: I recommend to write “. . .independent effects E of each driving factor Ci...”

P8 L15: Based on equation 3 I assume that the contributions of the climate variables are quantified by the absolute relative weights.

P9 L13-19: The first two sentences about sensitivity are to my perception not so relevant and could be deleted. I don’t fully understand the last sentence - does pooling mean averaging of results?

P11 L2: I would not use abbreviations in the title.

P20 L7-9: I think it is not necessary to mention in the conclusion that the Midwest has vast areas of croplands and grasslands, because this was not a major finding of the study.

P32 Fig. 2: The R-square values mentioned at P7 L16 could be added to the graph.

P36 Fig. 6: The figure caption explains the elements of a boxplot. If you think this is needed you should also add the explanation in Fig. 7 to be consistent. Additionally, I recommend to use the same y-axis labels in the two figures.

Please use the HESS guidelines for all abbreviations and units. E.g. P33 Fig. 3: adapt units from W/m2 to W m-2.

According to the HESS guidelines, authors are encouraged to briefly describe the

contribution of each co-author in a section called “author contributions”.

References:

Coopersmith, E. J., B. S. Minsker, and M. Sivapalan. "Patterns of regional hydroclimatic shifts: An analysis of changing hydrologic regimes." Water Resources Research, 50.3, 1960-1983, 2014.

Sawicz, K. A., Kelleher, C., Wagener, T., Troch, P., Sivapalan, M., Carrillo, G.: Characterizing hydrologic change through catchment classification. Hydrology and Earth System Sciences, 18(1), 273-285, 2014

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