Review of HESS Manuscript # hess-2016-588

Title: Historical and future trends in wetting drying in 291 catchments across China
Authors: Chen et al

The study examines changes in observed runoff and climate model projections for runoff over 291 catchments in China.

The topic is of broad interest and suitable for the journal.

I am very familiar with the topic because the basic approach was first set out in Roderick et al 2014 HESS. The manuscript reports on an important topic. The data are of great interest and the results are potentially important. However, I had a lot of difficulty in understanding the underlying scientific logic of the study.

The study is based on logic that tries to deduce a definition of wet and dry regions (based on a threshold in the aridity index) so that a DDWW (dry get drier and wet get wetter) interpretation can be used. The recommendation for China (page 11, lines 9-17) is to define wet/dry using an aridity index of 1 which gives a useful explanation for the observed trends in China using the DDWW approach (Fig. 3). However, as the author's note, the threshold for wet/dry will have to change from place to place (e.g. China vs Europe vs ….) to preserve a finding of DDWW (page 9, lines 3-10). I simply do not understand the scientific basis of that approach?

In terms of the underlying logic, the key result reported here was that in the 291 Chinese catchments, whether a place was considered wet or dry made little difference. Instead, places generally became wetter (i.e., runoff increased) when rainfall increased and generally became drier (i.e., runoff decreased) when rainfall decreased (as per Figure 5). The same analysis should be done for the CMIP output to see whether that result also held. In fact Roderick et al 2014 HESS showed that this dependence of runoff more or less solely on rainfall did hold globally in CMIP(3) model output but it would be useful to check that result using CMIP5 output for the 291 Chinese catchments studied here.

With that in mind, I suggest that the underlying logic/approach of the study needs to be completely re-evaluated.

You have observations and both model simulations and projections for 291 catchments. You know apriori that DDWW is from a hydrologic point of view, very unlikely, and you have previous results showing it does not hold. Why not use the same analysis that underlies Figure 5 to assess the CMIP5 model simulations (i.e. for the historic period) and projections (for the future)?

One thing to consider in the methodology is that the actual catchments will likely have non-climate related changes in the runoff as you acknowledge (page 3, lines 1-2). But you have not presented an approach to extract, for example, changes in land use and/or land cover that may have impacted runoff. It is reasonable to set dn = 0 (page 5, lines 24-25) for the climate model simulations/projections. How are you going to handle this for the observations? That was not explained?

Recommend: **Accept subject to revisions**

Comments

1. P2, line 10. Why the Greve reference? The original DDWW was Held and Soden 2006?

2. P 2, line 14, Why the Lim and Greve references? The point about the ocean dominance was originally made by Roderick et al 2014 HESS and was relevant to model projections and not observations.

3. P. 2, line 18. Why the Roderick reference? That paper did use the phrase salt get saltier, etc.., but the underlying results were from a paper by Durack? Perhaps say something like …… Oceanic observations (Durack et al 2012) confirm a fresh get fresher and salty get saltier pattern (as reinterpreted by Roderick et al 2014 HESS).

4. P. 2, lines 17-18. Another generalisation relevant here is that rainfall has increased in places with low rainfall and decreased in places with high rainfall (Sun et al 2012 GRL; Donat at al 2016 Nature Climate Change).

5. P. 4, line 6. You use Penman for PET. The earlier work by Roderick et al 2014 HESS actually followed Budyko and used net irradiance (and not Penman PET). Using Penman PET is not appropriate for vegetated surfaces when CO2 is changing (e.g. Roderick et al 2015 WRR, Milly and Dunne 2016 Nature Climate Change). For that reason you really need to consider using net radiation. It would be of interest to contrast the net radiation based results with those when the Penman PET is used.

6. Eqn 3. Why c? Later you use n (e.g. Eqn 4).

7. Eqn 7. Niether Arora 2002 or Fu et al used that form of the three-term partial differential equation. Why are they cited?

8. P. 6 line 26. Units. Here and elsewhere. The units of Q are mm a-1. The trend in Q has units mm a-2. The units of Annual Q are mm. The key here is that the prefix Annual denotes an integration. The trend in Annual Q has units mm a-1. So to use those units (mm a-1) for the trend you better put Annual in front of Streamflow at the start of the sentence. Same comment applies throughout.

9. p. 7, line 6. The sentence starting “However, in both situations ….” does not make sense?

10. P. 7, lines 7-11. What is the logic of this? See main comments at the beginning.

11. P. 9, Section 4.2. Why introduce new RESULTS in the DISCUSSION. I did not see the value of this entire section. However, if you want to keep it, then it needs to be moved back to RESULTS.

12. P. 10, Section 4.3. Same again. You cannot introduce new RESULTS in the DISCUSSION. If you want to keep it, then move it back to the RESULTS.

13. Fig. 12. Left Panel. This is truly astonishing. That is the best fit between modelled and observed rainfall I have ever seen! Are you sure of the analysis? I ask because the last sentence of the paper (p. 12, lines 1-2) says that the modelled rainfall was poor? But the results in the left panel of Fig. 12 are truly astonishing. Perhaps I have missed something?

14. P. 11, lines 20-23. This relates to the last comment in the main comments. On page 3, lines 1-2 you correctly point out the need to account for land-use and/or land cover changes. But you did not attempt that. This might be an English problem? Earlier (page 3, line 2) you need to say it is important but here we will ignore it – because that is what you did. Then at the end you need to say - we should not have ignored it (p. 11, lines 20-23). This whole part of the manuscript needs to be explained more clearly.

Michael L. Roderick, 1 December 2016