Comment on hess-2021-151

Steve Lyon

Community comment on "Land use and climate change effects on water yield from East African forested water towers" by Charles Nduhiu Wamucii et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2021-151-CC1, 2021

This study investigates climate and human impacts on water towers in East Africa. The analysis is conducted in a Budyko framework. The target region is often considered vulnerable to changes in water resources making this investigation warranted and the result likely informative. Overall, the study is well conceived. However, I feel there are some considerable limitations in the structure of presentation. Further, some of the mechanistic interpretations are not fully supported given the potential of confounding impacts and potential uncertainty in data and analysis.

In the introduction (especially around P2,L15-L20), I would expect to see some more consideration of the strengths and weaknesses of various approaches for assessing climate and land-use change on water resources. Do we have some results or previous work that are relevant for the region? What is the motivation for selecting the Budyko approach over other approaches? There is not much review of current science offered up in the introduction. This should be expanded to help the reader understand the motivations for the current study and approach.

In addition, the lack of framing the study in a research question or a hypothesis is a major weakness. The result is that the study is some exploration of data that does not seem to address a problem or help advance the science. Such exploration ("can-we-do-it" type of work) is fine for a technical report but more would be needed for publication in a peer-reviewed journal. I am confident the authors can put this study in a research framework and present a clean and testable hypothesis or a some societally relevant research question.

The study mixes direct observation data interpolated across sites and remotely sensed data at various scales. I'm wondering if there is any potential impact of the various assumptions and approaches in each dataset? Synthesizing across various approach can often compound huge amounts of uncertainties and errors as we build composite analysis (in space and time). How has uncertainty been considered in your analysis and what role would data error have on your results/interpretation? Some consideration and discussion of uncertainty impacts must be presented to help the reader understand how robust the findings are in this study. This should be fairly straight forward given how the water balances were constructed using 100 random points. Perhaps perform a re-selection of random point and assess the difference or use some sort of calibration/validation

approach on a sub-division of the 100 points (like a boot strap).

Further, I am not sure about the 100 random points in the methodology. Why was this done? Is it just too difficult to define the spatial extent of the water towers (which would allow using all the spatial data in the area)? Seems there would be some value in conducting this experiment at various elevations to assess the impact of elevation (as temperature proxy) on the results. Please outline why the method of 100 random point was selected and what the impacts would be on the results relative to another method.

There appears to be a large amount of mechanistic speculation on why points depart from the Budyko curve. There has been ample research over recent decades explaining how we can see variations along and from the curve. Further, many different explanations have been offered as to why catchments would deviate from theoretical curves with time. Could you outline some motivation for how you can be certain you are isolating mechanisms with your analysis? We would anticipate much interaction and coupled response that could be masked in the movement of points in Budkyo space (see van der Velde et al., 2014). It i likely that this lack of consideration of complexity relates back to the weakness and lack of thorough literature review seen in the introduction.

Along these same lines, what role would other factors such as CO2 increase and/or human alteration to water usage have in these regions? I could envision shifts in water cycling due to an intensification of plant activity through increased NPP or agricultural intensification. Warmer and CO2 richer climates could behave differently. Further, how much pumping and/or movement through irrigation schemes takes place in some of these systems? I understand they should be pristine or high-elevation forest without impact, but are they really without abstraction or other anthropogenic impacts?

In general, the results as presented are dense and not easy to follow. Read things a few times and not sure I can understand all the nuance of what is being shown here due to how things are being presented. This is not helped by poorly constructed figures with overlapping number, limited axis labels, and multiple colors to track. A major effort to organize the results into a concise section is required. Start by group the various results into sub-sections and cleaning up the figures. Structuring this section could also be aided by a more thoughtful research question or hypothesis setup. Then the results could be organized into how they answer the research question(s).

The discussion section is lacking rigor. At best it repeats the results with more interpretation. I miss a connection to the literature and how the results help inform and advance the science. Also, what are the strengths and limitations of the approach considered and how do these impact interpretation? Could not see what value the discussion added to the paper overall. Rather, it felt like the results were being explained again and the assumptions behind interpretation being ignored. Lastly, while there are no rules, the length of the discussion is rather short relative to the length of the results presented. In my experience, that can be indicative of a study that is exploring data rather than an experiment to test a hypothesis.

Minor edits

P1,L23: "atmospheric demand" is a bit wonky language for the abstract – could you phrase this differently?

P1,L35: Consider changing to "Mountain forests capture, store, purify and release water" to avoid ambiguity. Also, was "they" in reference to "mountain forests" or something else?

P2,L40: Are these all the water towers in the region? If so, state that. If not, justify why these towers.

P3,L4: The CRU data set is fairly course and known to contain rather few observations in Africa. Can you justify the use of these data here? Could another remote sensing product provide more accurate data?

P3,L4: I do not know how CRU gets PET. Could you provide some more information on how these data are prepared? This holds for all the data sets considered.

P3,L16: Break these longer sections up into sub-section to help the reader follow along.

P3,L31: What is "FU"?

P4,L11: 2011-2019?

References

van der Velde, Y., Vercauteren, N., Jaramillo, F., Dekker, S., Destouni, G., Lyon, S.W. (2014), Exploring hydroclimatic change disparity via the Budyko framework, Hydrological Processes, 28, 4110-4118.