Review of

Mekong River flow and hydrological extremes under climate change

(L. P. Hoang, H. Lauri, M. Kummu, J. Koponen, M. T. H. van Vliet, I. Supit, R. Leemans, P. Kabat, and F. Ludwig)

by

Erin Kunkel, Cyris Poutout, Camille Jourdan, Nawres Ben Jamaa, Mahamoutou Doumbia
(MSc students, Master EAU, University of Montpellier, France)

Introduction

This work is part of the MSc "Master EAU, parcours HYDRE (HYDrologie Risques Environnement)" at the University of Montpellier under the supervision of Valérie Borell-Estupina and Roger Moussa. The objective of the exercise is to improve the understanding of the peer review process. The students were free to select a manuscript from those recently published in HESSD, and were asked to respond to the evaluation criteria of HESS. We hope that the comments can help to improve the manuscript and the quality of the online discussion. We leave it up to the editor, reviewers and the authors to filter out the most relevant comments.

HESS manuscript evaluation criteria

1. Does the paper address relevant scientific questions within the scope of HESS?

Yes, the study of flow regimes in the Mekong basin and their response under climate change is within the scope of HESS. The scope of this journal is comprised of three major aspects, and this study falls exactly under the third category: the study of the interactions with human activity of all the processes, budgets, fluxes, and pathways as outlined above, and the options for influencing them in a sustainable manner, particularly in relation to floods, droughts, desertification, land degradation, eutrophication, and other aspects of global change.

2. Does the paper present novel concepts, ideas, tools or data?

This paper does not present new concepts or ideas, but it does present new data. This paper repeats work that has been done before, that is, executing a hydrological impact assessment based on predictive climate change data (Västilä et al., 2010) and (Lauri et al., 2006; 2012), but the authors use the most recent CMIP5 Climate change scenarios to complete this assessment. In their use of the latest data to complete their study, they update the current understanding of the Mekong basin's behavior under climate change. While this new data could be valuable to those looking to manage the water resources in the Mekong Basin, this study is really more of a work of engineering, because new data are analyzed by existing methods. However, this article is novel in its focus on hydrological extremes, since most previous studies focused only on changes at a monthly or seasonal timescale.

3. Are substantial conclusions reached?

There are two major conclusions reached in the article: The first is that temperature, precipitation, and discharge will all increase under climate change, but the variation between models highlights the need to be prepared for a variety of different scenarios. The second is that it is necessary to use an ensemble approach in hydrological assessments, to correct for the considerable differences in outcomes from the use of different GCMs. Neither of these conclusions is particularly groundbreaking, but it is certainly valuable to verify the behavior of the Mekong basin under climate change using the updated data.

4. Are the scientific methods and assumptions valid and clearly outlined?

The outline is made very clear in the introduction, and the methodology used in setting up the model was very clearly explained and justified with citations of other similar work, particularly (Lauri et al., 2006; 2012). The use of different climate models was explained and the choice of models was clearly justified in the discussion section.

5. Are the results sufficient to support the interpretations and conclusions?

Yes, but it is worth noting that the conclusions are very broad, discussing general trends in the Mekong watershed and their general implications.

6. Is the description of experiments and calculations sufficiently complete and precise to allow their reproduction by fellow scientists (traceability of results)?

The article explains the methodology in depth, although it relies heavily on citing other studies (Lauri et al. 2006 and 2012) for more precise details of how exactly the model was set up.

7. Do the authors give proper credit to related work and clearly indicate their own /original contribution?

Yes. They clearly explained and credited the previous work on which their model was built, and noted what aspects of their work and results were new or different from previous studies.

8. Does the title clearly reflect the contents of the papers?

Very clearly.

9. Does the abstract provide a concise and complete summary?

Yes. In general, the abstract was excellent, but it was not clear why the authors chose to note the annual change of +5% and +16%. This is the only numerical data presented in the

abstract, but it does not appear to be the most important data in the article, and it doesn't actually add any substance to the abstract. For these reasons it may be preferable to remove this from the abstract.

10. Is the overall presentation well structured and clear?

Overall, yes, the presentation is clear. One suggestion would be to move the section 2.1, which explains the characteristics of the watershed, into a new section titled "Study Area."

11. Is the language fluent and precise?

Yes, very well written, except on page 11658 line 12, there is a "u" missing in "rain gauge".

12. Are mathematical formulae, symbols, abbreviations, and units correctly defined and used?

Yes, all formulae, symbols, abbreviations and units are correctly defined and used.

13. Should any parts of the paper (text, formulae, figures, tables) be clarified, reduced, combined, or eliminated?

Yes, the introduction could be reduced because it is repetitive in its discussion of water resource scarcity and impacts of climate change on socio-economic development. For example, on page 11653, lines 6-7, the authors say "*Both demographic and economic trends imply an increasing importance of water resources for future socio-economic developments. (Pech and Sunada, 2008; Hoanh et al., 2010; Keskinen et al., 2010).*" In the next paragraph, lines 11-13, they repeat this sentiment "*Socio-economic developments in the Mekong River basin, however, are facing critical challenges relating to water resources, including hydrological changes caused by climate change (Keskinen et al., 2010; MRC, 2010; Västilä et al., 2010).*"

Figure 2 could be clarified by adding a time scale to the x-axis. Table 3 should instead be presented more like Figure 6. In Figure 6 we are able to see what each of the models predict, unlike in Table 3 where we can only see the ensemble mean, and then the minimum and maximum change for each station.

Figure 5 is too small, it is very difficult to see and compare the different curves shown in the graph. In addition, showing the relative discharge change as a percentage is misleading because it shows that there are enormous changes taking place between January and April, when in reality, there are just small fluctuations in low flows. It would be better to display this information as absolute change, not as a percentage (or eventually both absolute and relative), because the reader is really interested in knowing where the large amplitude changes are taking place.

14. Are the number and quality of references appropriate?

Yes, the number of references (65 total) is appropriate, and most importantly there are references for all of the data used in the study (GCMs, RCPs, and the CMIP5). The vast majority of references come from the last 10-15 years, only 4 of the references were published before the year 2000. This makes sense, given that climate science and modeling of future hydrological regimes are both fairly new disciplines.

15. Is the amount and quality of supplementary material appropriate?

N/A

Comments

0. Abstract

- In line 5, the authors say that this is "one of the first" hydrological impact assessments. If they say this, they should reference the other studies that completed assessments with CMIP5. However, because they don't have space (and it would be inappropriate) to reference multiple studies in the abstract, this phrase should not be included.

- In line 7, 11652 "(i.e. high and low flow conditions)" is really not necessary because it is explained later in the paper and most readers will understand what "extremes" means.

- In line 10, page 11652, the authors present the annual change between +5% and +16%. This is the only numerical data presented in the abstract, and it doesn't necessarily seem indicative of the overall results of the study. Later in the article the authors seem to focus on seasonal change, but they choose to present the annual change here. This phrase should be removed from the article.

- In the discussion and conclusion sections, the authors discuss the fact that certain areas show a reducing signal, and they remark that certain GCMs show considerable differences in precipitation changes and measures. While the authors devote considerable space to discussing these differences later in the article, and draw substantial conclusions from these specific results (i.e. saying that an ensemble approach is required for future hydrological assessments), they say very little about the implications of these uncertainties here.

1. Introduction

- The introduction is very repetitive. It does a good job of justifying the need for study by explaining the socio-economic challenges posed by climate change. However the authors repeat their ideas in this section and present more information than is really necessary to explain the motivation for the study.

2. Methodology

- Section 2.1 is a description of the study area and the hydrologic characteristics of this watershed. This section should not be in "Methodology." It should be in its own section or perhaps a subsection under the introduction called "Study Area".

- The hydrological model described in section 2.2 calls for the maximum, minimum, and average air temperatures. However, Figure 3 shows only the projected average change in daily mean temperature. It could be interesting to see the projected minimum and maximum temperatures as well.

- In section 2.3, it could be interesting to have a figure that shows the locations of the gauges used in the APHRODITE data set.

- Also in section 2.3, page 11660 line 13, the authors state that 2 degrees Celsius is an unrealistic target, but in Figure 3, several of the models show predicted daily mean temperature changes of more than 3 degrees Celsius. Therefore, it seems that 2 degrees Celsius, and the RCP2.6 that they eliminated based on their assessment, should be included as a realistic scenario.

3. Results

- In section 3.1 it would be useful to show the equations used to calculate the NSE and associated biases.

- In section 3.2, lines 18-19, the temperature patters are discussed very generally. It would be interesting to know more about the seasonal temperature changes that were observed, or to have more information about temperature changes with different scenarios.

- On page 11668, line 15, these two sentences could be combined to say "*Including other bias-correction methods is out of this paper's scope because*

our primary interest is to understand how the Mekong's hydrology will change under climate change."

- Section 3.3 references Table 3. This table provides the ensemble mean, and minimum and maximum changes in annual river discharge. However, it would make more sense to present this information in the same format as Figure 6, where we see the prediction from each model, not just the min, mean, and max. Visually, Table 6 is much better at communicating the information and allowing the reader to quickly comprehend the differences between the models.

4. Discussion

- The discussion is written more like a conclusion. It is natural that following a discussion of data, the authors may draw a conclusion or two within the discussion section. However, in this section, the authors not only draw conclusions, they also discuss the implications of these conclusions. For example, on page 11667, lines 15-19, the authors assess the implications of their results on the safety of hydropower dams. This certainly does not belong in the discussion section.

- This section discusses the many different GCMs that are used in the model. The authors discuss the importance of using many different GCMs, but of the GCMs used in this model, could any of them have been eliminated? Were there any that the authors felt skewed their results in an unrealistic way? For example, in Figure 8, one of the scenarios appears to be an outlier; its values are much lower than those of all the other scenarios. Would eliminating this scenario result in a more representative ensemble mean?

- In this section the authors discuss the possible uncertainties and complications inherent in combining multiple different data sets (page 11668). This discussion clearly explains the assumptions that they made when selecting this data and the steps they took to ensure that their data set was complete. However, this discussion may be better placed in section 2.3 where the climate data is introduced. If the authors want to leave this information in the discussion, it would be wise to at least say something in section 2.3 to the effect of "*limitations and potential sources of error will be discussed in section 4*." So that the reader isn't left questioning the validity of this data throughout the rest of sections 2 and 3.

- It could be interesting compare the results of this study to other applied simulations using the CMIP5 to know if similar results were found in other watersheds.

5. Conclusion

- Perhaps because of the conclusive nature of the discussion, the conclusion is very repetitive (for example, lines 10-15 on page 11666 are almost identical to lines 4-7 on page 11669). The authors need to revise the discussion and conclusion sections to better organize their ideas to fit into one section or the other.

- The authors should take time in the conclusion to discuss what other types of data collection or modeling would be useful to continue to improve the general understanding of the Mekong watershed. After setting up a model and completing such a detailed analysis of this model and its data inputs, they have a unique ability to identify what sort of studies could be useful to continue this type of work.

References

Hoang, L. P., Lauri, H., Kummu, M., Koponen, J., Van Vliet, M. T. H., Supit, I., … Ludwig, F. (2015). Mekong River flow and hydrological extremes under climate change. Hydrol. Earth Syst. Sci. Discuss, 12(12), 11651–11687. http://doi.org/10.5194/hessd-12-11651-2015

Hoanh, C. T., Jirayoot, K., Lacombe, G., and Srinetr, V.: Impacts of climate change and development on Mekong flow regime, First assessment – 2009, MRC technical paper no. 29, Mekong River Commission, Vientiane, Lao PDR, 2010.

Keskinen, M., Chinvanno, S., Kummu, M., Nuorteva, P., Snidvongs, A., Varis,O., and Västilä, K.: Climate change and water resources in the Lower Mekong River Basin: putting adaptation into the context, J. Water Clim. Change, 1, 103–117, doi:10.2166/wcc.2010.009, 2010.

Lauri, H., Veijalainen, N., Kummu, M, Koponen, J., Virtanen, M., Inkala, A., and Sark, J.: VMod Hydrological Model Manual, Finnish Environment Institute, EIA Ltd., Helsinki University of Technology, Helsinki, 2006.

Lauri, H., de Moel, H., Ward, P. J., Räsänen, T. A., Keskinen, M., and Kummu, M.: Future changes in Mekong River hydrology: impact of climate change and reservoir operation on 20 discharge, Hydrol. Earth Syst. Sci., 16, 4603–4619, doi:10.5194/hess-16-4603-2012, 2012.

Lauri, H., Räsänen, T. A., and Kummu, M.: Using reanalysis and remotely sensed temperature and precipitation data for hydrological modeling in monsoon climate: Mekong River case study, J.

Hydrometeorol., 15, 1532–1545, doi:10.1175/jhm-d-13-084.1, 2014.

Pech, S. and Sunada, K.: Population growth and natural-resources pressures in the Mekong River Basin, Ambio, 37, 219–224, doi:10.1579/0044-7447(2008)37[219:pganpi]2.0.co;2, 2008.

Västilä, K., Kummu, M., Sangmanee, C., and Chinvanno, S.: Modelling climate change impacts on the flood pulse in the Lower Mekong floodplains, Water Clim. Change, 1, 67–86, 2010.