Review of: "Understanding each other's models: a standard representation of global water models to support improvement, intercomparison, and communication" Camelia-Eliza Telteu et al.

The authors of this paper have used a standardised writing style for 16 global water models that provide simulations for the ISIMIP2b, with the aim of being able to compare the similarities and differences between the models. There is an extensive description of each of the models and the processes and components that are included in each. The amount of work that has been done here with respect to standardising all of the model's code is impressive! This cannot have been an easy task, and I believe the information that has been provided in the supplementary information will be of great value to the global hydrological modelling community. This paper also attempts to cover areas such as a literature review of the global water models used, the challenges that are associated with global hydrological modelling, and recommendations for future model intercomparison projects.

I do think that this work will make a good contribution to the work that has been done on model intercomparison, however, before it can be accepted there are some areas that need to be addressed. I will give my general comments in the next section, and then some more specific comments to the manuscript itself in the section that follows.

General comments:

1. The structure of the manuscript really needs some work and to be reconsidered.

The organisation of this manuscript doesn't seem to have been thought out thoroughly before writing. There is a lot of repetition in the sections. There is no real flow to the manuscript, which makes it difficult to follow and to see clearly what has been done, in what context, and what the outcome was. My recommendation would be to rethink the structure of the manuscript, and clearly define each of the sections with clear headings. I think the review of the literature and models would be better if it came before the discussion of the creation of the standardised writing style, and this would set out the context and the issues that frame the need for the study.

2. The actual substantial work that has been done, i.e. the standardising writing style for all of the global water models, needs more of a spotlight.

The description of the methodology used to create the standard writing style for the models lacks detail. This is the part of the manuscript that is substantial and novel, and what is being presented as the new contribution to the current knowledge and the hydrological modelling community. What I believe is missing is a detailed description of how you have standardised the model code. You mention in your manuscript that it was very difficult to find the similarities between the models especially between the different terms used. Therefore, without a clear methodology section, it is difficult for the reader to verify what you have done. It would be good to have a discussion of what the strengths and weaknesses of your approach are, and what are the issues/difficulties that you encountered along the way and how you managed to overcome these. Do you intend your method to be used beyond the models that are a part of ISIMIP2? Is this work intending to set out a roadmap, of sorts, for future work of a similar nature? I think to fix this issue, and to link with the previous comment, a dedicated methods section should be added to the manuscript.

3. This manuscript is trying to do far too more.

Your manuscript covers a lot of different areas. It covers the standardising of the model code, tried to review the literature of multi-model intercomparisons, and tried to look at the challenges that are face by the global hydrological modelling research community and attempts to provide recommendations for the future. I believe that each of these elements are very important, but for one paper to tackle each of these seems quite excessive. I think the review of the literature is valuable,

but it should form part of the introduction to the work, and 'set the scene' for the substantial work that has been carried out. I also think that you should consider cutting the manuscript down substantially. Section 5 is particularly long and it is almost impossible as a reader to take in all the information that is given. It would be much better to present these similarities and differences in the model in a more visual way. This section would also benefit from having less description of the models and more of a discussion of the implications of the similarities and differences that are found, e.g. do all the models seem to miss certain types of processes/model components?

Below are some specific comments that I had about each of the sections.

Specific comments:

Abstract:

- On page 2 line 53-55: *"Our results highlight that the predictive uncertainty of GWMs can be reduced through improvements of the existing hydrologic processes, implementation of new processes in the models, and high-quality input data."* – there is no mention in the abstract of how these kinds of conclusions are going to be made, what tests on the models performance are done, etc.

Introduction:

- The first paragraph is far too long. It would benefit from being broken into smaller parts. There is no clear focus either. It would be great if you could define clearly straight away what the paper is going to be about and the general context its in.
- Very long intro, consider streamlining, and concisely summarising previous MIPs, the usefulness of MIPs, and what has been learned from previous work. Use this as an opportunity to frame the context of the work that will follow.
- Maybe more information about hydrological MIPs would be useful. Page 3 Line 84 is the first time that you mention you are going to be comparing global water models.
- Page 3, line 83-85: use this as an opportunity to clearly state what exactly has been done in the work and how you have gone about achieving that. State the clear questions that have been identified from the literature review and what the gaps in the current knowledge are.

Section 2:

- Page 3, line 96-100: I think these communities are being brought together more in recent years and the boundaries between them are becoming blurred.

2.1. differences in modelling approaches:

- Some examples of LSMs, GHMs and DGVMs along with the descriptions would be beneficial for the reader.
- Page 4, line 109: you say daily, but many GHMs run at sub-daily time steps.
- The interchangeable use of LSMs and the climate community to me becomes confusing. Consider choosing one and sticking with it throughout the text.

2.2. ambiguity of terminologies used in hydrological modelling

- This section is definitely a good addition to this manuscript and useful for the read. However, this section lacks a real structure and focus. There are only 2 examples give (active vegetation and dynamic vegetation). This would potentially benefit with some smaller subsections with more examples of terminology ambiguities and how they are dealt with in the study.

- The final paragraph doesn't really fit with the rest of the information in the section. Again, consider restructuring and redefining what it is that you want to accomplish with this section.
- Page 5, line 144-149. Not sure if this information fits well in this section. Supposed to be discussing the ambiguities of terminology but instead are talking about why its important to include active vegetation in a model?

3.2. Steps taken to realise the standard writing style of model equations

- The first paragraph is all good information, but it might be better placed in the ambiguity of terminology. That would allow for a more description and definition of the terms that you have used.
- Page 6, line 191: could give some examples of parameterisation methods/techniques, include some relevant references.
- Page 6, line 186 and line 189: examples would be beneficial for the reader.
- I think this section is missing something about how you checked and made sure that the translation of the model code was in fact correct and robust. And provide this for the reader so that they have a way to validate what you have done.

3.3. Key characteristics of the global water models

- Extremely lengthy description of the models. All of this information is given in the tables and in the supplement. I know that a description like this is needed, but consider cutting this text back to make it more readable. Very easy to start getting a bit lost.
- Talk about using 12 catchments and 1319 gauging stations for calibration, but then how is this used? Is there some method of regionalisation of the parameters?

Section 4:

- Not sure if 'review' is the best word here. Makes the reader think you are going to talk through the strength/weaknesses and similarities/dissimilarities of the models.
- First paragraph may be better in the introduction. Could switch out some of the information in there already and change it for this. Some of the info in the introduction isn't really relevant to the state of global hydrological models/water models.

4.1. evaluation of global water model to observations

- This section feels more like a list of different studies and what they found. Not really sure how much value it adds to the manuscript. A review of what has been done on these models is important, but this section could be more concise to cut down some text.
- Some of this information could be incorporated into different sections.
- Maybe this review of studies should come earlier in the manuscript? Maybe put it as section 3 instead?

4.3. uncertainties in global water models

- Page 11, line 352-354 need a few references to some of these studies.
- Again, feels too much like a list of studies and what they found. I think the paper would be a lot more useful if these findings were written in a way that makes the work that is being presented make more sense.
- Page 12, line 366-367: "therefore, these is a need to better understand the models' structure complexity, their equations, and their approaches, and to improve the quality of the input data" this is a good example of explaining how the things that you have written about from the literature review link back to the work that you have done!!

- Page 12, line 369: this is more commonly referred to as Rainfall-Runoff Modelling Toolbox (RRMT).
- Could be good to add some insight into what has been learned from these different methodologies created by the catchment community.
- page 12, line 373-382: talking about the different approaches to parameterisation. This is the more detailed description of parameterisation approaches that would have been beneficial in section 3.2. maybe a little bit repetitive? I would consider moving some text around and combining sections to streamline the manuscript.
- Talking about the methods that have been developed by research communities (i.e. flexible frameworks and parameterisation methods) - is this really about the uncertainties, or is this a way of dealing with the uncertainties?
- Talking about the catchment modelling community at the end of the section. It might be good to introduce the catchment modellers somewhere formally to talk about how they are a part of the model development (Archfield et al. (2015), doi:10.1002/2015WR017498) good example of a paper that has a similar discussion

Section 5:

- Page 12, line 389: change this from 'among models' to 'models used in this study' or something else along these lines. Currently this reads ambiguously. Make it clear that you are talking about the ISIMIP models.

5.1. Similarities and differences in simulating the water storage compartments.

- For me this section is just too long and too dense. There is too much information, and it is nearly impossible as a reader to retain much of it. Unless you were reading this to look for specific information, it is too detailed. Consider cutting this text back substantially. Also consider thinking of a way to show this visually.
- This is mostly just a description of the hydrological cycle, and then which of the models represents these features and how. Not sure how valuable all of this information is to a reader.

5.2. similarities and differences in simulating human water use sectors

- Same comments as section before.

5.4. examples of how parameterisations can differ between GWMs

- The opening for this section is repetitive of information previously.
- Stating that the parameterisation and model structure lead to differing results. This is repeating previous points, and maybe stating the obvious?
- This section would benefit from a few examples of different parameterisation methods that have been used by a few of the models, and how much of an impact that has had on their simulations. I think this would make this section more valuable to the reader. As it is, I'm not sure of its relevance or impact.

5.5. How many water flows, water storage compartments, and human water use sectors are included in the GWMs?

- How are you defining these compartments here? Are you counting all of the different processes etc, or are you counting the layers that are in the model structure? I think this is a bit confusing.
- Telling the reader the number of compartments that each model has might not be that informative? It might be better to say what the effect of these different compartments are? Are models with more/less better/worse? What is the effect?

Section 6:

6.1. challenges in making this intercomparison study

- This section pretty much just talks about the challenges of terminology. Maybe it would be better if it was moved to the other part in section 3 where the challenges of terminology is introduced.
- I think quite a lot of this would be better as a part of a methods section. You have identified all the challenges and problems that you have come across and then explained how you overcame them. This is important in the defining of the standardised model equations. Consider moving all of this into a methods section.

6.2. Challenges in global hydrological modelling.

- Not sure what this has added to the article? Its very brief and doesn't really give any information to the reader. Consider removing. I think you are trying to add too much into this paper. Not sure how this is important. Yes there are many challenges in global hydrological modelling, but these should be the topic of focus of another piece of work all together.

6.3. recommendations for multi-model intercomparison projects.

- I think this whole section could be removed. Here I think you are trying to give recommendation for what MIPs should do in the future. However, the work that you have done and have presented is a dataset of standardised model equations.
- Again I think this is an example of where this paper is being over ambitious with its content.
- Page 23, line 753-757: this is good info. This shows that there is a good motivation for the work that you have done. This should go into the introduction or in a section where you are talking about the different research communities.
- Page 24, line 764-772: this is a good bit of this section. This is a good way of recommending to model developers etc how they can make their models more transparent. This also sort of creates a roadmap for how it would be possible to standardise models of the future. This section could be given a new heading, and make it more clear that this is the recommendation that is being made so that the work that you have done (i.e. standardising model code) can be reproducible in the future.
- Page 23, line 773-775: here you have identified what this paper is really lacking and what would make this a lot more palatable for the reader. Also easier to read and follow in general.

Section 7:

- You say that this was done to find the similarities and differences, which you have done and presented. I think what is lacking is a flavour of effect/impacts that this has.
- Page 27, line 886-887: the way you have rounded off this paper makes no sense, as you have presented no information about the performance of the simulations of the models themselves.