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Hydrology and Earth System Sciences Discussions

Interactive comment on "An integrated model for the assessment of global water resources – Part 2: Anthropogenic activities modules and assessments" *by* N. Hanasaki et al.

N. Hanasaki et al.

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Dear Reviewer

We are grateful for your comments to our manuscript. We are pleased that you acknowledged our papers as constituting a remarkable piece of work, well written, and applicable to wide range of problems. You expressed two major concerns over our manuscript: 1) lack of new understanding or insights, or novel application of our model; 2) uncertainty of our model. Here are our replies.

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This is the second of a 2-part paper. Together, these two papers constitute a remarkable piece of work, and very well written too. The model presented in these two papers will be widely used for a range of applications, and I commend the authors for this work. However, my biggest concern is what I can learn from this paper. The focus has been mainly on presenting the model details, demonstrating the improvements that have been made in respect of previous and contemporary models. For a paper to be published in a scientific journal, the model should have been used to generate new understanding or insights that we would not have otherwise, or novel applications of the model to answer fundamental or management questions. There is very little of it here. The authors may say that this may be beyond the scope of these two papers, but it is a serious concern.

In our papers, we raised a fundamental scientific question, and proposed a concrete answer to it by applying our new model. The scientific question we raised is described in the 1st paragraph of the "Introduction" section:

"Previous assessments of global water resources have projected current and future global water stress, focusing mainly on the spatial, rather than temporal, distribution of water resources and water use. A typical approach is to display the global distribution of per capita annual water resources (Arnell, 1999, 2004) or the withdrawal to water resources ratio on an annual basis (Vorosmarty et al., 2000; Oki et al., 2001; Alcamo et al., 2003a, b). However, extreme seasonality in both water resources and water use occurs in some parts of the world. Therefore, subannual variability must be taken into account."

The answer to this question is shown in "5.2 Newly developed index" sub-section, typically, in Fig 5. First, we devised a new index, Cumulative Withdrawal to Demand ratio (CWD) which can take seasonal water scarcity into account in water resources assessments. Then, we calculated

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the global distribution of CWD and compared with that of a contemporary annual-basis index, Withdrawal to Water Resources ratio (WWR). And we showed:

"A global water resources assessment was conducted using a newly devised indicator, the cumulative withdrawal to demand ratio, which detects water-stressed regions that were previously overlooked." (in "Conclusion" section)

In this way, we presented new understanding and insights to readers. Also our paper showed novel applications of our model, because the global distribution of CWD were achieved by our new model and elaborate simulations.

My second concern about these papers is that a lot of simplifying assumptions have been made to put together the model - I agree that they are necessary. Nevertheless, how much can I trust the predictions of the model, given these assumptions and simplifications. I would have liked to see some uncertainty analysis.

We have intensively described our model, compared our results with excellent earlier publications, and validated them with the best available observed records. In other words, we fully disclosed the uncertainties (assumptions, limitations, and achievements) of our model to readers. We admit that our model has considerable uncertainties in current stage, although we showed that many of them are the limitation of the state-of-the-art knowledge of global hydrology.

Here is a list where we validated our outputs and discussed about uncertainties.

- Input meteorological forcing: Section 3 (the final paragraph) and 8 (the 4th paragraph) in Part 1

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- Land surface hydrology module (and its parameters): Section 7.1-4 and 8 (the 3rd paragraph) in Part 1
- River routing module (and its flow velocity parameter): Section 6.4 in Part1
- Crop growth module (crop calendar): Section 4.1 in Part 2
- Crop growth module (Irrigation water demand): Section 4.2 in Part 2
- Reservoir operation module: Discussed in Hanasaki et al. 2006
- Environmental flow requirement module: Section 4.3 in Part 2
- Validity of key assumptions in integration: Section 3.3 in Part 2
- Overall performance and water scarcity index: Section 5.1, 5.3 in Part 2

Addressng these two concerns means submitting two new papers altogether, which is too much work, and perhaps too harsh. Perhaps as a compromise the authors can be persuaded to add a section at the end: 1) a listing of the assumptions and the improvements that are needed to the various modules, on the basis of improved data support and process understanding, and some measure of the confidence that they have with current modules; 2) the potential uses of the model - the kind of questions that can be answered with the model, and the insights that it can provide in terms of global hydrology etc.

Thanks for your proposal. Item 1 sounds a good idea, to summarize the achievements and limitations of our model in the "Conclusion" section, for example, between the 1st and the 2nd paragraph. Although it will duplicate the same information (most are already discussed in the sections listed above) and further increase the volume of our manuscript, we will wait for the editor's and other reviewer's comments. Item 2 is also a good idea,

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but we already described three potential applications in the "Conclusion" section:

"but it can be further used for virtual water estimation (Hoekstra and Hung, 2002; Oki and Kanae, 2004). It is also applicable for the impact analysis of water resource shortages on agricultural crop production, which can serve as another water stress index."

"Climate change is likely to alter future temperature and precipitation patterns and in turn alter the availability of renewable freshwater and water use. Our model can contribute to assessments of the effects of global warming on water resources by considering changing variation in precipitation, runoff, and water use".

We also described that many earlier studies for climate change impact on hydrology and water resources underlined urgent needs for the CWD-type water resources assessments:

"Arnell (2004) pointed out that according to the per capita water availability indicator, climate change would appear to reduce global water stress because increases in runoff are heavily concentrated in the most populous parts of the world, mainly in East and Southeast Asia, and tend to occur during high-flow seasons. Kundzewicz et al. (2007) argued that this might not alleviate dry season problems if the extra water is not stored, and it would not ease water stress in other regions of the world. A global water resources assessment under future global warming will be addressed in forthcoming papers."

Also, the authors may want to indicate if this model is going to be widely available for other groups. It will be a shame to independently develop the model - much can be gained by building on it.

Firstly, we are always happy to disclose all our program codes and

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scripts for academic purposes. However, because we are still working to advance our model, we have neither user manuals nor user-friendly codes and scripts. Taking into account our limited resources, we need much time to prepare them and have our model widely available for other groups.

Secondly, we welcome anyone who will collaborate with us to develop, improve, and apply our model. Likewise, we respect any efforts for other independent models, and want to learn from them.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 4, 3583, 2007.