**A point-by-point response to the reviews for "Reconstruction of global gridded monthly sectoral water withdrawals for 1971–2010 and analysis of their spatiotemporal patterns" by Zhongwei Huang et al**

Manuscript Details: Reconstruction of global gridded monthly sectoral water withdrawals for 1971-2010 and analysis of their spatiotemporal patterns, https://doi.org/10.5194/hess-2017-551

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We thank the reviewer for the very valuable comments and suggestions to improve the manuscript. Our point-by-point responses are listed below.

**Response to Anonymous Referee #2**

*Referee comments in Italics*

*GENERAL COMMENTS*

*This manuscript reconstructs gridded monthly water withdrawals globally for 6 sectors for 1971-2010 in a spatial resolution of 0.5\*0.5 degrees. The authors make this water withdrawal dataset publicly available, which makes the manuscript more valuable and is in the line of the open-access philosophy of HESS.*

*Such a detailed global dataset is indeed to my knowledge the first in its kind and very useful. The statement at the end of the document (page 14 lines 3-5) "In whole, despite the uncertainties and limitations, this study is of great significance not only for cross comparison and validation for modeling and analyzing the impacts of human water use, but also for investigating water use related issues at finer spatial, temporal and sectoral scales" is very true.*

*I also appreciate that the authors include an extensive part in their manuscript on uncertainty (Section 4), as they acknowledge the uncertainty and limitations of their study.*

*The manuscript is novel, well written and in the scope of HESS. I recommend for moderate revision, as some issues need to be additionally addressed/discussed first.*

Response: We appreciate the positive and constructive feedback from the referee on our manuscript.

*MODERATE COMMENTS*

*1) The authors use as basis FAO AQUASTAT data and state-scale estimates of USGS for the US as basis for downscaling. Yet, on page 3 Lines 1-15 they argue that particular countries provide more detailed (especially spatially) data than the FAOSTAT data. This is indeed true for Germany as the authors point out, but also for many other European countries. These data (and additionally from Canada, China, ...) could have been used to optimise the downscaling methodology the authors use. Why was this choice made for the US but not for these other sources? I find this a bit a missed opportunity. I acknowledge that this means a lot more work, but you could have used all best data available instead of the US selection. Nevertheless, this does not have to be done within this paper, but maybe in future work. Please discuss shortly in the limitations section (section 4) of your manuscript.*

Response: Thanks for your thoughtful comments. We agree with the reviewer that we could have improved the spatial downscaling if we collected subnational sectoral water withdrawals for these countries. We also agree with the reviewer that such an extension would amount to a lot of additional work and should be tackled in future research. Such an effort would also raise some additional challenges. For example, the definitions of sectoral water use are potentially inconsistent because these data are reported by various organizations and institutions. We only use FAOSTAT and USGS data in this study, but we can update the open-access datasets after we obtain the subnational sectoral water withdrawal data for other regions or countries. In the revised manuscript, we have further discussed the limitations of this work and potential future work needed to improve the reconstructed dataset.

*2) SPATIAL DOWNSCALING TECHNIQUES: For some sectors (domestic, irrigation, livestock) the downscaling techniques are state of the art, for other sectors (electricity for cooling, mining and manufacturing) they are very rough. The three latter are based upon population-density maps. This is a very rough approach, as these sectors are in my opinion not always highly correlated with population densities. Water abstractions for cooling can very well be concentrated outside urban centres, for security reasons (e.g. nuclear power plants) and the availability of large water quantities (e.g. along rivers).*

*Nulear water abstraction which can be substantial can thus be concentrated as point intake in a more rural area. Manufacturing industries have in developed countries often moved outside urban centres (where in the past they were often in city centres). Last but not least, mining activities often take place in remote areas, and large water abstractions can be very concentrated on a small rural spatial scale. When you produce a 0.5\*0.5 degree geo-dataset, these considerations can be very relevant. I acknowledge that the authors briefly describe limitations on page 12 lines 24-27. They also say this is a topic for further research. But please elaborate more on this, in the line with the argumentation I just made.*

Response: Thanks for your thoughtful comments. We agree with the referee that the spatial downscaling techniques for some sectors (e.g. electricity generation, mining and manufacturing) are rough. Water withdrawal for electricity generation is affected by many factors, including the location of power plants, the amount of generated electricity, generation type, cooling technology, and fuel types. As mentioned by the referee, water withdrawal for cooling can be concentrated outside urban centers for security reasons (e.g. nuclear power plants) and the need for large water quantities (e.g. along rivers). Also water withdrawal for mining and manufacturing are related to the geographic locations of mines and manufacturing centers, respectively. We have incorporated these points into the discussion of the limitations of the spatial downscaling techniques and future work in our revised manuscript.

*3) MISSING SECTOR TOURISM: The authors include 6 sectors, the ones which are typically identified for abstracting water. However, as in most studies, some particular water abstraction sectors are excluded. As indicated in the publication https://doi.org/10.1016/j.ecoser.2015.08.003, an important generally neglected sector is tourism. This includes water abstractions for snowmaking, which during winter months in mountain areas can be the largest regional water user (https://doi.org/10.2166/wst.2009.211 ). This water is generally taken from surface water, and is not accounted for in municipal water abstraction statistics. But this also includes water abstractions for hotels/swimming pools/spas both in winter and summer tourist areas (e.g. https://doi.org/10.1016/j.tourman.2013.05.010 ). These water users often have own private water abstractions, which are not accounted for in domestic/ municipal water use statistics. E.g. in Mediterranean regions during summer months these water abstractions can become shortly the dominant water use. Another touristic water user are golf courts (e.g. https://doi.org/10.1094/ATS-2009-0129-01-RS). These touristic water abstractions can on a local (0.5\*0.5 degree) and temporal (monthly) level be very significant. Please include in your discussion section a short subsection on this topic, based upon my input. Future research should include the sector tourism.*

Response: Thanks for your thoughtful input. We didn't consider tourism sector due to the lack of global water withdrawal dataset on tourism. In the revised manuscript, we have discussed the need for considering the missing sectors (e.g. tourism).

*4) SECTORS FORESTRY and AQUACULTURE: As indicated in the publication https://doi.org/10.1016/j.ecoser.2015.08.003, these sectors also account for water abstractions. Again, on a global level they may not be very significant in quantity, but on a local (0.5\*0.5 degree) and temporal (monthly) level, they can be very significant. Is forestry accounted for in your irrigation sector? Aquaculture can be very significant in a country like China. Please include in your discussion section a short subsection on this topic.*

Response: Thanks for your valuable inputs. Water use for forestry and aquaculture sector are important components of total water use. Here, aquaculture water withdrawal are included in livestock sector in our study, because FAO AQUASTAT provides water withdrawal for irrigation and total agricultural sector (i.e. water withdrawn for irrigation, livestock and aquaculture purposes), and livestock water withdrawal are calculated by the difference between agricultural and irrigation water withdrawal. We ignored water withdrawal for forestry sector in this study. In the revised manuscript, we have clarified that aquaculture water withdrawal is embedded in livestock water withdrawal, and have further discussed the significance of considering the forestry and aquaculture sectors in future work.

*5) DOMESTIC WATER ABSTRACTION: Please define in your paper what you mean with this. There is often confusion in the terminologies domestic and municipal water abstractions. There is a difference in water abstractions by households (generally defined as domestic water abstractions) and municipal water use, which additionally includes water use by shops, schools, public buildings ... and even for the cleaning of streets or public parks. As I understand your definition of "domestic sector" also includes these water users. Include a definition.*

Response: Thanks for your kind comments. Domestic water withdrawal in this study is the water use for indoor household purposes such as drinking, food preparation, bathing, washing clothes and dishes, flushing toilets, and outdoor purposes such as watering lawns and gardens, and also includes water use for the part of the industries and urban agriculture (e.g. water use by shops, schools, public buildings, and for the cleaning of streets or public parks). We have added the definition of water withdrawal by sectors in the revised version.

*MINOR COMMENTS*

*Page 2 line 19: You discussed the impact on the hydrological cycle and humans. Please add a sentence about the negative impact on the environment*

Response: Thanks for your kind comment, and we have revised the manuscript as suggested.

*page 2 Line 22 'We focus in this study on water withdrawal" - This is a choice, as also water consumption is an important statistic of water use. Water stress e.g. can be computed with both, as discussed in a recent publication https://doi.org/10.1016/j.scitotenv.2017.09.056*

Response: We agree. Water consumption is an important statistic of water use, and we also reconstructed the global gridded sectoral water consumption dataset, which will be also published together with water withdrawal data through an open-access link. Because the methods for reconstructing water consumption data are simple, we focus in this study on water withdrawal. The details of water consumption data have been represented in supplement materials.

*Page 3 line 7: Please add that also other selected European countries provide more detailed water use statistics (especially spatial data).*

Response: Thanks for your kind comment, and we have revised the manuscript as suggested.

*Page 3 Lines 18, 19: GHM and LSM - define abbreviation first*

Response: Thanks for your kind comment, and we have spelled out global hydrological model (GHM) and land surface model (LSM) for their first use in the revised manuscript.

*Page 4 Line 14 ... (GCAM): please add ref*

Response: Thanks for your kind comment, and we have added the references.

References:

Edmonds, J. et al., 1997. An integrated assessment of climate change and the accelerated introduction of advanced energy technologies-an application of MiniCAM 1.0. Mitigation and adaptation strategies for global change, 1(4): 311-339.

Kim, S.H., Edmonds, J., Lurz, J., Smith, S.J., Wise, M., 2006. The objECTS Framework for integrated Assessment: Hybrid Modeling of Transportation. The Energy Journal: 63-91.

*Page 6 Line 14: ... 30 urban centers ... : Urban water use characteristics can actually be quite different from rural water characteristics. By only downscaling based upon urban water use characteristics, the resulting dataset could be biased in temporal representation for more rural areas*

Response: We thank the reviewer for this excellent suggestion, and future work should certainly consider the distinction between rural and urban seasonal patterns. This will depend on the availability of monthly water use data in rural areas to facilitate such an exercise. As far as we know, there is no such a data product, and collecting monthly data for rural water is proved to be challenging as apparent by the number of countries with such data (Table 2). We have discussed this limitation in our revised manuscript.

*Page 8 Lines 17-21: Water abstraction for livestock: there are actually formulas that relate livestock water use to temperature.*

Response: Thanks for your comments. There are possible formulas that relate livestock water use to temperature. But we don't have monthly livestock water use data to parameterize such formulas. Thus, we applied the uniform distribution in this study. We have discussed about this point in the revised manuscript.

*Table 1: Please add a column with the spatial resolution of these datasets*

Response: Thanks for your comments. We have revised the table as suggested.

*Figure 3: (c) Electricity and not elecreicity.*

Response: Thanks for your comments. We have revised this in new manuscript.