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October 31, 2022

Response to reviewer comments for:

"Global monthly sectoral water use for 2010-2100 at 0.5° resolution across alternative futures"
(Manuscript ID: SDATA-22-00583), submitted to Nature Scientific Data

Reviewer Comments Received: 01 August 2022

Dear Chief Editor Guy Jones,

We would like to thank you and the reviewers for your invaluable feedback and comments. Please find a list of all editor and reviewers' comments we received followed by an explanation of where and how each comment has been addressed in the revised manuscript. We think that with the suggested changes the paper has become much stronger.

Thank you for the guidance,

Sincerely,

Zarrar Khan

Contents

List of All Reviewer Comments

The following is a list of all reviewer comments received on **31 May 2022**. Each comment has been addressed in the text as described in the corresponding section. Comments are numbered by referee as R1 for Referee 1, and E1 for Editor.

E1 Comment 1: Please ensure that your references conform fully to the Nature style. See the examples at the link below: http://www.nature.com/sdata/publish/submission-guidelines

E1 Comment 2: Note that "meta-repository" is not a widely understood term at this journal. If I understand correctly, this provides wider explanations of the methods used and external links to other deposited resources (e.g. Tethys v1.3.1 at Zenodo). Please note that:
- All experimental methods relating to this work should be available in the manuscript itself. I understand that a lot of this content may be duplicated in the paper, but if not, I would encourage you to share any additional workflow, validations, Basin examples, etc within the paper. A single supplementary document can be used if there are large amounts to add. Data visualizations are fine to share soley on this site as long as the underlying data has been been formally deposited
- All external resources should be cited in the manuscript - use the reference list for any citable objects with formal metadata (i.e. DOIs, author names, etc) and simply embed the ULRs in the text in ()s for websites without these. From quick inspection it looked like all the links were in the former category (i.e DOI'd objects that can be formally cited). Again, it looks like a number of these are already included in the paper (e.g. the Code Availability statement), but please check and confirm there is nothing exclusively shared at the met repository.

E1 Comment 3: Please change the Custom licence terms for the Dataverse dataset to a recognizable open licence (CC0 and CC-BY are usually required for this journal).

E1 Comment 4: Please add a data citation for the Dataverse dataset to the reference list using these instructions (https://www.nature.com/sdata/publish/submission-guidelines#data_citations - note that a DOI URL should be used). Please add the reference number to wherever the dataset is mentioned in the text - the main position should be the first part of the Data Record in a sentence describing where the data has been deposited.

E1 Comment 5: Please also formally cite the items listed in the table in the Code Availability sections in the reference list. Please also note that all tables need a table label and a legend.

R1 Comment 1: Please provide a more detailed description of basin boundaries and selection principles in the manuscript.
- Discovery of the problem: Irrigation water accounts for a higher proportion of the total water consumption in the region, and the combination of region and basin can indeed be better constrained. But I am confused about the basin boundary in Figure 2 and how to select the basin for constraints. For example, the boundary of the Yangtze River Basin in Asia is not correct ([1], etc.), and the Yukon River Basin in North America [2] mentioned in the background that there is irrigation in the Basin, but is not isolated in Figure 2.
- References:
  [1] Zhang Q, Xu C, Becker S, et al. Sediment and runoff changes in the Yangtze River basin during past 50 years. Journal of hydrology, 2006, 331(3-4): 511-523.
  [2] Yang D, Zhao Y, Armstrong R, et al. Yukon River streamflow response to seasonal snow cover changes. Hydrological Processes: an International Journal, 2009, 23(1): 109-121.

R1 Comment 2: Please give a reasonable explanation for the degree to which the historical data results deviate from the 45° curve, and add the verification of the historical water data in time and space.

- Discovery of the problem: The dataset is to serve users, and the first consideration of users should be more about the quality of the dataset. When verifying the reliability of downscaling, the downscaled data must be compared to the original input data. However, the quality of the dataset also includes the accuracy of the water withdrawal/consumption data in time and space, this needs to be verified and should be reflected in the manuscript [3]. (1) Since neither the manuscript nor the meta-repository has found the result data used for the verification of this paper, the data verification has not been carried out. It is recommended to add the result data of the historical period of this article in the data set to facilitate the verification of the historical period for users and reviewers. (2) Through the comparison of two similar datasets in the meta-repository (Huang et al. 2018, Mekonnen, M.M and Hoekstra, A.Y. 2011), the discrete differences between regions can be explained,but the degree of deviation from the 45° curve doesn't seem to be well answered. (3) Therefore, it is further suggested to supplement the manuscript validation section with the available tabular data or integration results of government departments (such as USGS water withdrawal, water resource bulletins in China, etc.) or international organizations (FAO-AQUASTAT data). Comparison with the regional statistical results in this manuscript [4].
- References:

[3] Chiarelli D D, Passera C, Rosa L, et al. The green and blue crop water requirement WATNEEDS model and its global gridded outputs. Scientific data, 2020, 7(1): 1-9.

[4] Zhang, K., Li, X., Zheng, D., Zhang, L., Zhu, G. (2021). Satellite-based Global Irrigation Water Use data set (2011-2018). National Tibetan Plateau Data Center, DOI: 10.11888/Hydro.tpdc.271220. CSTR: 18406.11.Hydro.tpdc.271220.

R1 Comment 3: Please add the verification of future forecast data in the manuscript.

- Discovery of the problem: There may not be a similar combination method and cannot be accurately compared for the future sector's forecast data. But the similarities, differences ,trends or ranges of its predictions can still be compared in some aspects [5-6]. Future forecast data is another key content in the manuscript, and the availability needs to be further analyzed.
- References:

[5] Wada Y, Bierkens M F P. Sustainability of global water use: past reconstruction and future projections[J]. Environmental Research Letters, 2014, 9(10): 104003.

[6] Fujimori S, Hanasaki N, Masui T. Projections of industrial water withdrawal under shared socioeconomic pathways and climate mitigation scenarios. Sustainability Science, 2017, 12(2): 275-292.

R2 Comment 1: First, the methods of temporal downscaling are similar to Huang et al., 2018. The authors were required to demonstrate the manuscript's novelty.

R2 Comment 2: Second, there are no detailed description that can be applied to future water withdrawals and consumption in the Methods chapter.

R2 Comment 3: Third, the authors do not provide rigorous verification. The content of the technical validation section does not guarantee the accuracy and availability of this dataset.

R2 Comment 4: The manuscript describes the importance of water withdrawals and consumption, but the research progress on spatial and temporal downscaling methods is insufficiently described. Authors should explain the limitations of existing spatial and temporal downscaling methods and clearly explain how they have addressed them in this manuscript.

R2 Comment 5: L30-63 This paragraph is about the models and datasets used in this manuscript, which is more like what is in the Methods chapter. The authors should have organized the logical structure of the Background & Summary chapter.

R2 Comment 6: The Region/Basin Scale (Electricity and Irrigation) in figure 3 shows a very large differences in water withdrawals between adjacent regions, so how did authors deal with making the spatial distribution smooth in the Gridded Scale in Figure 3, because there are some regions with clear boundary in the northern Africa and in the northern North America. Meanwhile, many methods of spatial downscaling are average methods, how did authors ensure the accuracy of results between adjacent regions. In addition, how did authors eliminate the impact of some cross-regional water transfer projects and water facilities on the spatial downscaling of water withdrawals and consumption.

R2 Comment 7: L361-370 Authors did not validate the accuracy of the water withdrawals and consumption. Although the spatial and temporal downscaling methods were validated, the results of this validation verification are obvious according to the methods presented earlier by authors. It is recommended that authors increase the comparison results with statistics published by government agencies to prove the accuracy of the historical part of this dataset.

R2 Comment 8: L375-402 Authors explains some differences between this dataset and the other two datasets, but do not explain in detail whether these differences will affect the accuracy of the results. Furthermore, although the authors list the scatterplots of the validation with other datasets on a meta-repository, they do not give detailed explanations. The correctness of the validation results is not known only from Figure 5 and 6. Using the data of only one year (2010) is not very convincing. It is recommended that the author extend the period (e.g., 2005-2010) of validation results of this dataset and other datasets in detail to prove the stability of the prediction data.

R2 Comment 9: There are some regions with clear boundary in the Gridded Scale of Figure 3, such as in Sahara in Africa and in northern North America. What is the reason for this situation?

R2 Comment 10: In the formula 15 and 16, two identical "$temp_{max}$" appear in the denominator.

R2 Comment 11: There is no label in the first figure of "Temporal" of Figure 4b.

R2 Comment 12: L238 What is the meaning of "pρ values"?

E1 Comment 1

Response:

- We have checked the references and bibliography to ensure we are complying with the "Nature" citation style as detailed in the link provided: http://www.nature.com/sdata/publish/submission-guidelines

E1 Comment 2

E1 Comment 2: Note that "meta-repository" is not a widely understood term at this journal. If I understand correctly, this provides wider explanations of the methods used and external links to other deposited resources (e.g. Tethys v1.3.1 at Zenodo). Please note that:
- All experimental methods relating to this work should be available in the manuscript itself. I understand that a lot of this content may be duplicated in the paper, but if not, I would encourage you to share any additional workflow, validations, Basin examples, etc within the paper. A single supplementary document can be used if there are large amounts to add. Data visualizations are fine to share soley on this site as long as the underlying data has been been formally deposited
- All external resources should be cited in the manuscript - use the reference list for any citable objects with formal metadata (i.e. DOIs, author names, etc) and simply embed the ULRs in the text in ()s for websites without these. From quick inspection it looked like all the links were in the former category (i.e DOI'd objects that can be formally cited). Again, it looks like a number of these are already included in the paper (e.g. the Code Availability statement), but please check and confirm there is nothing exclusively shared at the met repository.

Response:

- As suggested all relevant models and data products are now referenced in the paper itself in the Code Availability section. In addition, all equations describing the methodology are also repeated in the paper. The meta-repository is only provided as an additional reference to visualize the full dataset without the need to download it.

E1 Comment 3

E1 Comment 3: Please change the Custom licence terms for the Dataverse dataset to a recognizable open licence (CC0 and CC-BY are usually required for this journal).

Response:

- We have updated the terms to CC-BY in the custom dataset terms.

Edits Made:

- Dataverse terms updated to CC-BY.
  https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/VIQEAB -> Terms.

E1 Comment 4

Response:
- We have added citations for all the data and software products with DOIs and cited throughout the document and in the final table.

Edits Made:
- Citations added for all products with DOIs

E1 Comment 5

Response:
- We have added citations for all the data and software products with DOIs and cited throughout the document and in the final table.

Edits Made:
- Citations added for all data and software products
- Table label and legends added to all tables

R1 Comment 1

Response:

- The basin boundaries are based on the underlying input data coming from the GCAM model so these were not selected as part of this study. We have added a reference for the readers to the relevant studies which discuss in detail the selection of the basin boundaries (Moirai [1,2]) in the land data system used by GCAM. The basin boundaries are aggregated from watersheds, and named after both river basins and coasts, so some area of a river basin may be part of the coast and included in that boundary instead. Additionally, Figure 2b shows the intersection of GCAM regions and basins, which will cause basins that are shared between regions to be divided even further.

  1. Di Vittorio, A.V., Vernon, C.R. and Shu, S., 2020. Moirai Version 3: A Data Processing System to Generate Recent Historical Land Inputs for Global Modeling Applications at Various Scales. *Journal of Open Research Software*, 8(1), p.1. DOI: http://doi.org/10.5334/jors.266
  2. Narayan, Kanishka, Di Vittorio, Alan, & Vernon, Chris. (2021). GCAM boundary spatial products from moirai v3.1 (1.1.0) [Data set]. Zenodo. https://doi.org/10.5281/zenodo.4688451

Edits Made:
- Methods section, added "(these boundaries[28] are determined by Moirai[29], the land data system used by GCAM)"
- Figure 1 updated to clearly show that this study is only working with the downscaling of outputs from previously published GCAM outputs which were at the basin scale.

R1 Comment 2

R1 Comment 2: Please give a reasonable explanation for the degree to which the historical data results deviate from the 45° curve, and add the verification of the historical water data in time and space.

- **Discovery of the problem:** The dataset is to serve users, and the first consideration of users should be more about the quality of the dataset. When verifying the reliability of downscaling, the downscaled data must be compared to the original input data. However, the quality of the dataset also includes the accuracy of the water withdrawal/consumption data in time and space, this needs to be verified and should be reflected in the manuscript [3]. (1) Since neither the manuscript nor the meta-repository has found the result data used for the verification of this paper, the data verification has not been carried out. It is recommended to add the result data of the historical period of this article in the data set to facilitate the verification of the historical period for users and reviewers. (2) Through the comparison of two similar datasets in the meta-repository (Huang et al. 2018, Mekonnen, M.M and Hoekstra, A.Y. 2011), the discrete differences between regions can be explained, but the degree of deviation from the 45° curve doesn't seem to be well answered. (3) Therefore, it is further suggested to supplement the manuscript validation section with the available tabular data or integration results of government departments (such as USGS water withdrawal, water resource bulletins in China, etc.) or international organizations (FAO-AQUASTAT data). Comparison with the regional statistical results in this manuscript [4].

- **References:**

[3] Chiarelli D D, Passera C, Rosa L, et al. The green and blue crop water requirement WATNEEDS model and its global gridded outputs. Scientific data, 2020, 7(1): 1-9.

[4] Zhang, K., Li, X., Zheng, D., Zhang, L., Zhu, G. (2021). Satellite-based Global Irrigation Water Use data set (2011-2018). National Tibetan Plateau Data Center, DOI: 10.11888/Hydro.tpdc.271220. CSTR: 18406.11.Hydro.tpdc.271220.

Response:
- As pointed out by the reviewer one aspect is the validation of the downscaled data as compared to the original aggregated dataset which is clearly demonstrated in Figure 4.
- Additionally, the underlying data has been previously validated for both historical and future time periods in Graham et al. 2018.

*Graham, N. T., Davies, E. G. R., Hejazi, M. I., Calvin, K., Kim, S. H., Helinski, L., et al. (2018). Water sector assumptions for the Shared Socioeconomic Pathways in an integrated modeling framework. *Water Resources Research*, 54, 6423– 6440. https://doi.org/10.1029/2018WR023452

- All data from the Tethys outputs are made available in the linked dataset on dataverse with a DOI and freely downloadable for independent checks by any user.
- In this paper we compare the spatial and temporal gridded data against two datasets (Huang et al. 2018 and Mekonnen, M.M and Hoekstra, A.Y. 2011) to verify the spatial and temporal distributions. In the paper we limit this comparison to figures 5 and 6 which show similar patterns for both spatial and temporal distributions albeit with some differences that are attributed to different years of studies and different underlying data sets.
- In the meta-repo we include additional cell-by-cell comparisons for the interested reader, however the aim of the paper is not replicate cell by cell distributions from other studies but provide a dataset that covers broad range of future scenarios using a transparent methodology. For the cell-by-cell comparisons some additional explanations include:
  - For the comparison with Huang et al. 2018 on the metarepo, the strong lines are a result of the same population proxy being used to downscale country scale data, rather than region scale data, as some countries will have a higher or lower per capita demand than the region they are part of (reflected in the slope of the line).
  - The difference in the irrigation sector is because a different irrigation proxy was used in this study as compared to Huan et al. 2018. This study uses dynamic irrigation area evolution based on the outputs of the Demeter model.
  - Some difference with Mekonnen, M.M and Hoekstra, A.Y. 2011 can be attributed to a difference in data year, as that study is meant to characterize the years 1996 through 2005, which is close but not identical to 2010. Additionally, proxy quantities likely don't replicate all details of actual water demand, especially when compared at a grid cell by grid cell basis, but the overall spatial distribution is similar.

R1 Comment 3

R1 Comment 3: Please add the verification of future forecast data in the manuscript.
- Discovery of the problem: There may not be a similar combination method and cannot be accurately compared for the future sector's forecast data. But the similarities, differences ,trends or ranges of its predictions can still be compared in some aspects [5-6]. Future forecast data is another key content in the manuscript, and the availability needs to be further analyzed.
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[5] Wada Y, Bierkens M F P. Sustainability of global water use: past reconstruction and future projections[J]. Environmental Research Letters, 2014, 9(10): 104003.
[6] Fujimori S, Hanasaki N, Masui T. Projections of industrial water withdrawal under shared socioeconomic pathways and climate mitigation scenarios. Sustainability Science, 2017, 12(2): 275-292.

Response:

- Verification of the global and region-scale, historical and future forecasts for the underlying GCAM water use outputs was carried out in Graham et al. 2018 (https://doi.org/10.1029/2018WR023452) which we have now made reference to in the text. The work done for this publication is the downscaling of those projections to gridded scale, and we include the comparison with Mekonnen and Hoekstra (2011) and Huang et al. (2018) to show that these downscaling methods reasonably reproduce the spatial and temporal distributions. The same downscaling methods are then applied to the future forecasts which have been independently validated at the basin scale in https://doi.org/10.1029/2018WR023452.

Edits Made:

- In Technical Validation, added "Sectoral comparison between GCAM's future water demand projections and other studies is carried out in the supporting information of Graham et al. 2018*."

*Graham, N. T., Davies, E. G. R., Hejazi, M. I., Calvin, K., Kim, S. H., Helinski, L., et al. (2018). Water sector assumptions for the Shared Socioeconomic Pathways in an integrated modeling framework. *Water Resources Research*, 54, 6423– 6440. https://doi.org/10.1029/2018WR023452

R2 Comment 1

R2 Comment 1: First, the methods of temporal downscaling are similar to Huang et al., 2018. The authors were required to demonstrate the manuscript's novelty.

Response:

- We do employ the same techniques as Huang et al., 2018 (which themselves were developed in earlier papers) for temporal downscaling.
- The novelty in this dataset comes from:
  - Applying these techniques to future years across 75 combinations of SSP, RCP, and GCM for users to be able to explore the water data across this set of possible futures.
  - An improved methodology for spatial downscaling of irrigation water demands based on the dynamic evolution of irrigated area by crop type coming from the Demeter model which was run on the same set of scenarios. Huang et al. 2018 used a static spatial proxy for irrigation water demands based data from GMIA[1] (2005) and HYDE[2] (2000)

  1. Siebert, S., Henrich, V., Frenken, K., and Burke, J., 2013. Global Map of Irrigation Areas version 5. Rheinische Friedrich‐Wilhelms‐University, Bonn, Germany / Food and Agriculture Organization of the United Nations, Rome, Italy. http://www.fao.org/nr/water/aquastat/irrigationmap/index10.stm
  2. Klein Goldewijk, K., Beusen, A., Van Drecht, G. and De Vos, M., 2011. The HYDE 3.1 spatially explicit database of human induced global land use change over the past 12,000 years. Global Ecology and Biogeography 20(1): 73‐86. DOI: https://doi.org/10.1111/j.1466‐8238.2010.00587.x.

Edits Made:
- Background and summary expand to highlight the novelty in this paper i.e. the application of previous methods to the 75 different scenarios as well as the use of dynamically evolving irrigation area to inform the spatial distribution of irrigation water demands.
- Figure 1 updated to clearly show contributions from this paper vs. past studies.

R2 Comment 2

R2 Comment 2: Second, there are no detailed description that can be applied to future water withdrawals and consumption in the Methods chapter.

Response:
- Verification of the global and region-scale, historical and future forecasts for the underlying GCAM water use outputs was carried out in Graham et al. 2018 (https://doi.org/10.1029/2018WR023452) which we have now made reference to in the text. The work done for this publication is the downscaling of those projections to gridded scale, and we include the comparison with Mekonnen and Hoekstra (2011) and Huang et al. (2018) to show that these downscaling methods reasonably reproduce the spatial and temporal distributions. The same downscaling methods are then applied to the future forecasts which have been independently validated at the basin scale in https://doi.org/10.1029/2018WR023452.

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R2 Comment 3

R2 Comment 3: Third, the authors do not provide rigorous verification. The content of the technical validation section does not guarantee the accuracy and availability of this dataset.

Response:
- We have added a reference to the validation of region-scale water demand inputs from Graham et al. 2018., which compares those values to other projections to assess their reasonableness, and we verify that these conditions are satisfied in this data set.
- The methods used for spatial and temporal downscaling are verified on historical data in their respective papers, so the quality of the spatial and temporal detail in this data set is dependent on how suitable these techniques continue to be in the future, as well as uncertainty in the proxies. We included an example comparison with data for the year 2010 as a way of illustrating the degree to which these methods reproduce spatial distribution patterns of demand.

R2 Comment 4

R2 Comment 4: The manuscript describes the importance of water withdrawals and consumption, but the research progress on spatial and temporal downscaling methods is insufficiently described. Authors should explain the limitations of existing spatial and temporal downscaling methods and clearly explain how they have addressed them in this manuscript.

Response:

- This dataset utilizes existing downscaling algorithms from peer-reviewed publications.
- An improved proxy for dynamic irrigation landuse area by crop (using outputs from Demeter) for each scenario is used to better represent the evolution of irrigation water use. is used to improve.
- Since this manuscript primarily concerns the dataset and not the development of new downscaling techniques, we have limited the discussion to an overview of similar datasets and not downscaling methodologies.

R2 Comment 5

R2 Comment 5: L30-63 This paragraph is about the models and datasets used in this manuscript, which is more like what is in the Methods chapter. The authors should have organized the logical structure of the Background & Summary chapter.

Response:

- As suggested, we have reorganized and rewritten the background and summary chapter with increased emphasis on the background and moved the details on the models and dataset to the methods section.

R2 Comment 6

R2 Comment 6: The Region/Basin Scale (Electricity and Irrigation) in figure 3 shows a very large differences in water withdrawals between adjacent regions, so how did authors deal with making the spatial distribution smooth in the Gridded Scale in Figure 3, because there are some regions with clear boundary in the northern Africa and in the northern North America. Meanwhile, many methods of spatial downscaling are average methods, how did authors ensure the accuracy of results between adjacent regions. In addition, how did authors eliminate the impact of some cross-regional water transfer projects and water facilities on the spatial downscaling of water withdrawals and consumption.

Response:

- While total withdrawals can vary largely between adjacent regions, these are often strongly related to total population or total land area, so withdrawals per grid cell may actually be very similar near the border.
- Additionally, most of a region's large withdrawals usually belong to a small number of cells (such as those containing cities), and as a result the distribution at the border appears fairly smooth without additional consideration of boundary effects on our part, although these effects likely do exist in some manner.
- Cross basin transfer is not modeled as part of our downscaling, as we are looking at location of water demand, not physical water supply.

Edits Made:

- In Methods, added "While many adjacent regions differ largely in total water demand, most of this demand is directly related to total population or land area, and often concentrated in a few cells, such as those containing cities. As a result, spatial distributions at the border are smoother than they appear on the region scale map, without additional consideration of the boundaries by Tethys."

R2 Comment 7

R2 Comment 7: L361-370 Authors did not validate the accuracy of the water withdrawals and consumption. Although the spatial and temporal downscaling methods were validated, the results of this validation verification are obvious according to the methods presented earlier by authors. It is recommended that authors increase the comparison results with statistics published by government agencies to prove the accuracy of the historical part of this dataset.

Response:

- Verification of the global and region-scale, historical and future forecasts for the underlying GCAM water use outputs was carried out in Graham et al. 2018 (https://doi.org/10.1029/2018WR023452) which we have now made reference to in the text. The work done for this publication is the downscaling of those projections to gridded scale, and we include the comparison with Mekonnen and Hoekstra (2011) and Huang et al. (2018) to show that these downscaling methods reasonably reproduce the spatial and temporal distributions. The same downscaling methods are then applied to the future forecasts which have been independently validated at the basin scale in https://doi.org/10.1029/2018WR023452.

Edits Made:

- In Technical Validation, added "Sectoral comparison between GCAM's future water demand projections and other studies is carried out in the supporting information of Graham et al. 2018*."

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R2 Comment 8

R2 Comment 8: L375-402 Authors explains some differences between this dataset and the other two datasets, but do not explain in detail whether these differences will affect the accuracy of the results. Furthermore, although the authors list the scatterplots of the validation with other datasets on a meta-repository, they do not give detailed explanations. The correctness of the validation results is not known only from Figure 5 and 6. Using the data of only one year (2010) is not very convincing. It is recommended that the author extend the period (e.g., 2005-2010) of validation results of this dataset and other datasets in detail to prove the stability of the prediction data.

Response:
- The verification of the underlying dataset at coarser resolution is carried out in past peer-reviewed studies which have been referenced to in the text. The downscaling methods used in this study are based on methods from previous studies and have been transparently explained. These methods use simple proxies such as population distribution, irrigated area and livestock maps. The limitations of these methods are discussed in the Usage chapter and the downscaling results will be improved with improved proxy maps in future versions of the model.
- Verification of the global and region-scale, historical and future forecasts for the underlying GCAM water use outputs was carried out in Graham et al. 2018 (https://doi.org/10.1029/2018WR023452) which we have now made reference to in the text. The work done for this publication is the downscaling of those projections to gridded scale, and we include the comparison with Mekonnen and Hoekstra (2011) and Huang et al. (2018) to show that these downscaling methods reasonably reproduce the spatial and temporal distributions. The same downscaling methods are then applied to the future forecasts which have been independently validated at the basin scale in https://doi.org/10.1029/2018WR023452.

Edits Made:
- In Technical Validation, added "Sectoral comparison between GCAM's future water demand projections and other studies is carried out in the supporting information of Graham et al. 2018*."

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R2 Comment 9

Response: These clear boundaries are a byproduct of the areal-weighting method used in the proxy population data https://sedac.ciesin.columbia.edu/data/collection/gpw-v4/methods/method1, meaning population counts were only available at the scale of those visible regions, and population was assumed to be uniformly distributed among cells (in proportion to land area). These clear boundaries can also appear in the irrigation sector when using the crop distribution directly as a proxy would lead to a situation that would imply more irrigated land than total cell area, so the remaining demand is reallocated uniformly across the rest of the region, resulting in clear boundaries.

Edits Made:
- In Spatial Downscaling – Non-Agriculture: "Large groups of cells with the same value are a byproduct of the areal-weighting method used in the proxy, where coarse census data are evenly distributed."

R2 Comment 10

Response: The corrections to the formulas have been made.

Edits Made:
- Replaced with be (temp$_{month}$ - temp$_{mean}$)/(temp$_{max}$ - temp$_{min}$)

R2 Comment 11
<mark>**R2 Comment 11: There is no label in the first figure of "Temporal" of Figure 4b.**</mark>
Response: The words have been added.

Edits Made:
- TODO: ~~photoshop~~ inkscape the words "By Sector" onto the figure.

R2 Comment 12
<mark>**R2 Comment 12: L238 What is the meaning of "pρ values"?**</mark>
Response: This formatted wrong, and has been corrected to "ρ values," which are proportions for electricity referred to in the formulas earlier.

Edits Made:
- Removed the extra p