Dear referee,

Thank you very much for reviewing our paper titled "Simulating human water impacts on global water resources using VIC-5" and for your valuable comments and suggestions. Below we address your comments (shown in italic), with our responses in blue.

Model performance

The referee suggests that we should further evaluate model performance *"compared to observed sectoral and/or global water withrdrawals".* These suggestions were also addressed by the other reviewers.

We agree with these suggestions and we will include a rigorous evaluation of the hydrological model performance. We will compare model simulations with observations and/or reported data on discharge, total water storage, reservoir storage and sectoral water demands. As included in the response to the other reviewers, the following approaches are proposed:

1. Simulated discharge will be compared with monthly timeseries and multi-year average discharge from the GRDC dataset, between 1980 and 2010. Stations are selected within the major river basins of the original VIC calibration paper of Nijssen et al. (2001). Naturalized discharge as well as human-modified discharge simulations will be compared in this manner.
2. Simulated total water storage will be compared with monthly timeseries, multi-year-average total water storage and inter-annual water storage trends from the GRACE satellite dataset, for the period 2004-2016. To do so, a 300km gaussian filter will be applied to the simulated total water storage, as it is in the GRACE dataset. Total water storage will be compared for the same river basins as in the discharge comparison. Naturalized and human-modified total water storage simulations will be compared in this manner. These results will also include the unmet water demands, subsequent non-renewable groundwater abstractions and long-term total water storage exploitation.
3. Simulated sectoral water demand will be compared with monthly timeseries from the Huang et al. (2018) dataset. This is in addition to the comparison to the Shiklomanov (2000) dataset and FAOSTAT (FAO, 2016), EUROSTAT (EC, 2019) and WWDR (Connor, 2015) datasets already used in the paper. Sectoral water demands will be compared for the world and for the 5 regions used in this paper (Africa, Americas, Asia, Europe and Oceania); and separately for each sector (irrigation, domestic, industrial and livestock) separately.

4. Simulated reservoir inflow, storage and release will be compared with monthly timeseries from Yassin et al. (2019) (assuming this data is shared), Rougé et al. (2019) and Hanasaki et al. (2006) datasets. Dams are selected based on data availability and evaluation will focus on large dams.

Novelty

The referee comments that the *"methodology itself lacks in novel advancements"* and, in the specific comments, that *"It should be more carefully noted throughout the text the novelty of what is being added to the modeling community"*. Claims regarding its use in modelling the water-food-energy nexus *"may be misleading"* and, in the specific comments, that such conclusions *"should be clarified"*. This was also commented by another reviewer.

With regard to the notions of methodological novelty: we agree that the incorporated modules are based on previous major works. However, the integration of these modules is a clear improvement compared to previous VIC studies. Our model study includes the full range of water-use sectors (including domestic, industrial, energy and livestock), which have been estimated independently. Also, the routing module was fully integrated in VIC-5, which was not possible in previous VIC versions. This heavily decreases computation times for human-impact studies and provides a much improved framework for other future human-impact studies. Water-use sectors can also use groundwater as a resources, which directly impacts baseflow and thus downstream (dry-season) water availability.

With regard to the notions of the water-food-energy nexus: we agree with the referee that notions towards the modelling of the water-food-energy nexus may be misleading. We will therefore remove these sentences from the manuscript, and rewrite part of the discussion.

For a full description of all proposed changes we refer to our responses to referee 1.

Specific comments

"Line 328: the study is mentioned to use varying socioeconomic predictors. These could be better explained in section 2.3.2 in order to specify where GDP and GVA are obtained."

We will add an explanation to section 2.3.2, based on section 7.4.1.

Lines 243-244: "Domestic and industrial water withdrawals were estimated based on Gross Domestic Product (GDP) per capita and Gross Value Added (GVA) by industries respectively."

Will change to: "Domestic and industrial water withdrawals were estimated based on Gross Domestic Product (GDP) per capita and Gross Value Added (GVA) by industries respectively (from Bolt et al. (2018), Feenstra et al. (2015) and World bank (2010); see section 7.4.1 for more details)."

"Lines 406-408: "To our knowledge no previous study has estimated the amount of

global non-renewable groundwater withdrawals without using on the the models mentioned above" - see Turner et al. (2019) or Kim et al. (2016) for additional groundwater withdrawal modeling capabilities."

We thank the referee for these useful citations, which we will incorporate into the text.

"Line 426: "Note that VIC-WUR does not include non-renewable groundwater withdrawals, while these withdrawals would affect baseflow to a lesser degree" - I am confused, then why was there a discussion on about this in paragraph starting at line 400? Maybe consider reorganizing these thoughts.."

The discussion in the paragraph starting at line 400 assumes that all unmet water withdrawals originate from non-renewable sources. However, this does not mean that models actually include simulations of non-renewable groundwater withdrawals. To make this distinction clearer we will include more detail about the model setup used in the results, and we will reorganize the discussion.

We hope the referee agrees with the changes made, and are open to any further suggestions or comments.

Sincerely,

Bram Droppers on behalf of all co-authors

References

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Shiklomanov, I. A.: Appraisal and assessment of world water resources, Water Int, 25, 11-32, Doi 10.1080/02508060008686794, 2000.