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Hydrology and Earth System Sciences
Discussions
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Interactive comment on "A seawater desalination scheme for global hydrological models" *by* Naota Hanasaki et al.

Anonymous Referee #1

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The manuscript describes a new routine for incorporating seawater desalination dynamics in a global hydrologic model in this case the H08 model. The work is certainly an advancement over the current of the start of the art and how GHMs currently handle seawater desalination. So the work is of interest to the readership and would likely help advance the representations of desalination in GHMs. However, there are several major concerns especially with the proposed Seawater Desalination Model structure and the appropriateness of the validation exercise. I recommend major revisions.

Major concerns:

- The criteria for selecting desal plants (e.g, 613 from the 17,000 available in DesalData), the amendment of records as necessary such as in mountainous areas, and the selection of thresholds for the proposed conditions (e.g., 0.1 AI, 165km) seem ad

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Discussion paper

hoc and subjective, and irreproducible by others in case of the adjustments to the data. Also why was the model calibrated/tested for two countries and not all the countries for which desal exists? Also why not use procedures such as decision trees or regression decision trees, or the like to establish those thresholds based on the actual data as opposed to the guessing of thresholds?

- The validation of the SDM is inadequate. First, capturing the spatial distribution over a snapshot in time is an important element, but equally important is the ability of the model to simulate the evolution over time especially since the study considers desal water withdrawal over time as a central focus of the study. Second, the modeling approach is employing 3 conditions and assumptions as discussed in the paper to generate a gridded dependency map of areas dependent on desal plants globally with the goal to compare them to an observational dataset (DesalData) in this case. However, the only serious validation was a visual comparison between the results of Figure 4 and the desal plants location in two countries, Saudi Arabia and UAE. This visual comparison of the results (not even on the same figure and limited to two countries when the intent is to apply globally) is not sufficient to justify the appropriateness of the model. Also in figure 4, for example, the simulated areas/grids of area utilizing seawater desalination are widespread over much larger areal extent than the distribution of where the cities are located. For example, many of the inland grids between some of the major cities in the west of Saudi Arabia hardly have any population presence and a population based estimate might be more appropriate. Obviously many of these grids exhibit minimal water demands and where the major cities lie is what matters, but again this highlights the inadequacy of using figure 4 as the validation of the model. Also the comparison of country scale results is not sufficient to justify how the desal water withdrawals are distributed within a country. I would recommend expanding the validation exercise to global scale. For example, a scatter plot of total desal water use at the country scale for multiple time periods over history would help fill in this gap. Extending Figure 1 to show the global map and comparing that to Figure 5a would also be useful to show if the areas popping out as desal dependent over history are consistent with where the desal plants are located around the globe.

- The first key question in the paper of looking at figuring out the common climatic and socioeconomic conditions associated with usage of seawater desalination around the global is a very interesting and important question, but as discussed in the previous two comments, the authors did not approach this in a systematic way and barely scratched off the surface in addressing this question. The paper is really mainly focused on the second question outlined by the authors.

- Why limit the analysis to large and seawater plants only? Also in many regions the use reverse osmosis and brackish water is more prevalent and in some cases many of the plants are actually inlands like in the US. Expanding to take a more holistic look at all of desal water use would make the paper a lot more useful to the scientific community.
Minor concerns

Line 15: change ‘likely’ to ‘projected’

Line 16: I would omit the term ‘modern’ throughout the manuscript when describing GHMs

Line 18: specify the historical period

Line 26: I would suggest to add a sentence or two at the end of the abstract to state the implications of those estimates (or provide a range of the fraction of local GDPs in countries that depend on desal or maybe translate the estimates to total energy instead of cost and compare to total energy consumption)

Line 80: 46.9 km3 sounds extremely large. Are you using the correct unit? It is confusing that units are km3/yr in the text and million m3/day in the tables. I would use consistently.

Line 84: it is not clear to why only Major Plants.

Line 85: ’29.3’ is the production or capacity? Also it would make the sentence more informative to include the values for the other categories as well.

Line 91: ‘erroneous’ how were these circumstances adjusted. Clearly explain (maybe in SM) to ensure reproducibility of the work also who many data points were adjusted?

Line 105: add ‘for each grid’ before globally.

Line 110; I suspect there were both downscaled and bias-corrected. I would add a sentence to state so with a reference for completeness.

Line 127: to avoid having to send the readers to previous publications, I would suggest to consider reproducing these figures/table in the supplemental materials. Even better would be to tabulate the results at the country scale for the historical and future scenarios and placing them in an Excel file as a supplementary document.

Line 182: what does it mean to have 110

Line 213: why use 40-80 when the data says 28-77? How was that approximation done?

Line 269: I would show these numbers as fraction of regional or global GDPs. I would suggest doing this at the country scale at the least and giving a range.

Line 299: less than triple

Line 302: the increase of population from 14.5 to 184.3 million sounds really large! Is this due to the assumption of static population distribution within a country?

Table 1: what does other mean? I think adding a footnote to explain this sector and the value of 35 in Spain would be useful

Table 3: why 2055 in particular?

Table 4: several comments

- Replace ‘historical’ with ‘historical (2005)’

- I would suggest using consistent units with those in the text (km3/yr).

- I would suggest adding or even replacing the last column on the right because it is hard to draw any conclusion from the total production cost. One option is to compute the range of the percent of GDP at the country scale to highlight that this maybe a substantial value in countries like Qatar or UAE for example. Another option is to look at the total energy associated with the production of that much desal and then compare to the total primary consumption in that country (in a way this would isolate the GDP portion not related to the energy sector). But the latter will like take some additional work so it may suffice to do the first option.

- Also consider adding the estimates from the study of Kim et al (2016). Balancing global water availability and use at basin scale in an integrated assessment model. Climatic Change, DOI 10.1007/s10584-016-1604-6

Figure 1: I would suggest adding 3rd figure at the bottom showing the whole globe and maybe showing all the plants excluded from the analysis in gray color. Also is color scale for capacity of production?

Figure 2: this is solely based on two countries and I would imagine that it should vary based on the size of the country and the distance from saline water bodies should matter in defining this threshold.

Figure 6: I would suggest omitting this figure and adding the results to table 4.

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