Response to Reviewer 2

The paper presented by Hanasaki et al. developed a new modeling scheme for seawater desalination water use that can be applicable to existing global hydrological models. The newly developed desalinated water use scheme was then applied to project future desalinated water use under different socioeconomic (SSPs) and climate change (RCPs) scenario. It was found that future desalinated water use is expected to increase substantially (about 2-15 times), however, the future estimates vary significantly depending on different socioeconomic pathways. To my knowledge, this study provides most comprehensive results for historical and future desalinated water use estimates and projections across the globe. The author used the latest and very comprehensive data source, DesalData (http://desaldata.com/), and incorporated them into a global hydrological model. Existing global or large-scale studies on desalinated water usetypically use the data from FAO AQUASTAT, WRI EarthTrend, EuroStat, and available country statistics, which often have very limited global coverage. The authors combined the desalination data with other socioeconomic data (GDP, population, production cost, etc) to construct the Seawater Desalination Model (SDM). The paper is topical and presents interesting and useful findings, and it is concise and mostly wellwritten. The newly developed SDM is useful for large-scale modeling framework, and appears to be quite applicable to other GHMs. However, I do have some comments regarding the methodologies that were applied in SDM as detailed in the following.

> Thank you very much for taking time to review and providing insightful comments. All of the concerns you raised have now addressed as below.

1. The methodologies described in Section 2.4 is the key part of this study. The section is concise, however, it currently lacks rationales for those conditions and assumptions (A-C) made in the SDM. The methodologies appear to be quite arbitrary at its present form. Since this study focuses on developing a new desalinated water use model, these key parameters need to be described more thoroughly. I urge to expand Section 2.4 and provided further explanations of each key parameter, condition, and assumptions that have been incorporated in the SDM. These information are very useful for other large-scale hydrological modelers. Without further explanations, the novelty of this study is very limited. In addition, I suggest to combine Section 3.1 into Section 2.4. Section 3.1 is basically the method and background information that derived the key parameters.

> Thank you for this comment. Now Section 2.4 is further elaborated. First, taking the

comments and questions of Reviewers 1 and 2, we have elaborated the concept of SDM and parameters (lines 148-157). In the original discussion paper, the parameters (thresholds in Conditions A-C and Assumptions A-C) are suddenly appeared without sufficient explanation. Now it is clearly described how the parameters were derived (lines 165-171 and 177-186). Because many reviewers and readers like to distinguish methods and the results of data analyses, we kept the subsections 2.4 and 3.1 as is, but we further edited for readability.

2. Some assumptions made for the SDM are not entirely reasonable. For example, the cost of desalinated water use is decreasing and the efficiency of desalinated water use is improving in recent years. For future projections (towards 100 years later), further technological improvement is expected to reduce the cost drastically. The assumption made based on a historical trend may not be applicable for the future, e.g. desalinated water use for irrigation. In addition, fossil groundwater reserves are actively used in the Middle East and Northern Africa (MENA) despite the near zero natural recharge. The authors may include fossil groundwater use estimates to isolate the impact on desalinated water use. I would suggest to at least discuss these uncertainties further.

Thank you. We completely agree with you that technology advances and subsequent cost reductions will enhance the introduction of desalination plants. We noted that this mechanism is not included in SDM in lines 428-432. Note that importance of this mechanism and possible distortion of simulation results have been already discussed elsewhere (lines 386-390). Also, this mechanism have been partly analyzed in the sensitivity test of changing the threshold of Condition A (minimum per capita GDP; Figure 7): the decrease in the threshold corresponds to diminish in the relative cost of desalination. We also fully notice the importance of alternative water sources. As you pointed out, the production of desalination is largely determined by the availability of renewable/fossil groundwater. This could be partly achievable if we combine SDM with the global hydrological model that explicitly simulate renewable/fossil groundwater. We added discussion in lines 432-434.

3. The uncertainty inherent in future water use estimates needs further discussion with some quantitative information (e.g., Wada et al., 2016).

Wada, Y., Flörke, M., Hanasaki, N., Eisner, S., Fischer, G., Tramberend, S., Satoh, Y., van Vliet, M. T. H., Yillia, P., Ringler, C., Burek, P., and Wiberg, D.: Modeling global water use for the 21st century: the Water Futures and Solutions (WFaS) initiative and its approaches, Geosci. Model Dev., 9, 175-222, doi:10.5194/gmd-9-175-2016, 2016.

Thank you. Wada et al. (2016) is particularly relevant to Section 3.5 “Key uncertainties and implications”. We cited this paper and mentioned that the water use projections substantially differ among models and systematic model inter-comparison is under way (lines 411-412).

4. I find the results presented are very interesting, and in particular, the substantial ranges in future desalinated water use estimates among different SSPs are intriguing. However, currently the paper focuses primarily on a global scale estimate but I think it is more beneficial to focus on regions and highlight the change in desalinated water use per country in MENA or other parts of the world. For example, the information like “As shown in Table 4, the volume of seawater desalination was estimated at 3.7 $km^3yr^{-1}$with a cost of 1.5–14.0 109 USD, equivalent to 0.0025%–0.024% of total global GDP.” is no so informative, in my opinion. This type of information should be provided at a country basis, since the regional heterogeneity of desalinated water use is extremely large.

In the revised manuscript, we showed the change in the volume of seawater desalination for 11 regions in the world in terms of desalinated water production (Table 5) and cost (Table S3 and S4). Discussion is shown in lines 317-337.

5. Global figure like Figure 5 is not so informative, and I suggest to zoom in to some regions like Figure 4. This is a global scale study, but it should highlight more the regions of interest. The majority of the map is blank in Figure 5. The information density is very low.

Thank you for your suggestions. We tried your idea but it was not very successful. Due to income growth by the mid of 21st century, regions including AUSD increases substantially in all continents which makes the figure highly complex.

6. Additional information on surface water availability per country (in some tables) for the future period would be useful to highlight the importance of desalinated water use. Water availability is generally projected to decrease over e.g., the Mediterranean.

Thank you. This is an important point. Now we have added discussion in lines 379-381.

7. I suggest the authors to make a similar table like Table 4 but focusing on some regions (Middle East, Mediterranean, etc). Table 4 is useful for a global comparison, but additional information on regional desalinated water use is also very useful including historical estimates and future projections like Table

1.

Thank you for this suggestion. As stated above, regional projections are now shown in Tables 5, S3, and S4. Discussion is shown in lines 317-337.

8. When you describe “14,000 USD”, please be careful that this indicates per capita GDP only. Please check this throughout the manuscript.

Thank you for noticing this. We have checked the unit of per capita GDP throughout text.

9. The term “modern GHMs” is not clearly defined and not commonly used. This is rather confusing, what it is exactly indicating, e.g. model representations, framework, human components, etc. This should be corrected.

Thank you. We’ve also received similar comment from another reviewer. Now we removed adjective “modern” from text. The original intention was global hydrological models including latest treatment of human activities, but we agree that the adjective was simply confusing.

10. I think this study is important highlighting the significance of desalinated water use for coming decades. The paper can be a bit restructured with more regional focus. In principal, I would recommend this paper to be considered for publication after some revisions.

Thank you. Now we have revised our paper trying to include your suggestions as much as possible. We believe now the paper has been substantially improved including extended discussion on regional results.