We would like to thank Reviewer 2 for the insightful comments which helped us a lot to improve the manuscript. Below you will find our response to each comment. The reviewer's comments are shown in italic and the responses are shown in bold letters.

#Reviewer 2

Comments on "Enhancement and validation of a state-of-the-art global hydrological model H08 (v.bio1) to simulate second-generation herbaceous bioenergy crop yield" by Ai et al. The ms shows modeling implementations and results of global simulations of switchgrass and Miscanthus yields, and effects of irrigation in the simulations. I appreciate the courageous work to validate global simulations of energy crops, however, the ms doesn't provide any original scientific insight; it just adopts modeling information from SWAT model. Also, the ms doens't incorporate various insight from researches on energy crops, for example, suitable energy crop species in tropics, importance of fertilizer applications on marginal land, etc. I have several concerns about the ms, and I do not find the ms ready for publication in present form. I must recommend publication in another outlet specific to bioenergy researches (e.g. Biomass and Bioenergy, GCB Bioenergy,...) after substantial revision.

Response: We appreciate the detailed and insightful comments. We well take all your concerns. We totally agree with you that our study does not include every aspect of bioenergy and our crop model is simple. Still we believe this study contains substantial original scientific insights. Also this study tries to shed light on irrigation which is one of the factor often missing in large-scale studies. We also think this paper is within the scope in GMD since this study proposes a functional extension of the well-established global hydrological model called H08.

We found the reviewer's main concern is the scientific insight. Therefore, we would like to give specific explanations below.

The primary targeted energy crop here is the so-called second-generation herbaceous bioenergy crop, namely Miscanthus and switchgrass. The primary

spatial scale here is global. Under this circumstance, we give quite comprehensive review of previous reports on yield simulations of Miscanthus and switchgrass and emphasized the progress of global-scale studies. To do so, we identified the limitations and gaps in previous studies as follows:

1) **The systematic calibration and extensive validation of models need to be improved at a global scale. For example, the modelling work on LPJmL was calibrated manually (Beringer et al., 2011; Heck et al., 2016), and the simulation work based on HPC-EPIC was calibrated systematically but lacked independent validation and further model inter-comparisons (Kang et al., 2014).**
2) **To the best of our knowledge, the effect of irrigation on the yield of both Miscanthus and switchgrass, particularly their water use efficiency (WUE) in different climate zones at the global scale, has not been well studied.**
3) **Simulations have generally been performed for either Miscanthus (Clifton-Brown et al., 2000, 2004; Hastings et al., 2009) or switchgrass (Kang et al., 2014), with only few studies of both (Trybula et al., 2015; Ojeda et al., 2017; Beringer et al., 2011; Li et al., 2018b; Miguez et al., 2012).**
4) **Previous studies have generally been conducted at the regional or continental scale (Clifton-Brown et al., 2000, 2004; Hastings et al., 2009; Trybula et al., 2015; Ojeda et al., 2017); few have been conducted at the global scale (Beringer et al., 2011; Heck et al., 2016; Kang et al., 2014; Li et al., 2018b).**
5) **Despite their importance, the key parameters for Miscanthus and switchgrass and their differences have only been well documented in a few studies (Trybula et al., 2015).**
6) **Except for the LPJmL model, few models can simulate the bioenergy crop yield with full consideration of human activities in the water sector, such as irrigation, reservoir operation, and water withdrawal.**

This study well filled such gaps and limitations by enhancing and validating the H08 global hydrological model with human activities. This is realized through much efforts like collecting more observed or simulated data, transparent parameters tuning, clear parameters setting, and so on. Compared with earlier studies, our study made several important improvements as below:

1) **Rather than using an approximation for C4 grass to represent Miscanthus and switchgrass in the LPJmL model, our enhanced H08 model simultaneously simulated the yields for Miscanthus and switchgrass at the global scale.**
2) **We conducted both site-specific calibration and independent country-specific evaluation with more observed data (as can be seen in Table 3) and predicted data (from the MISCANMOD, HPC-EPIC, and LPJmL models).**
3) **Because of the importance of transparent parameter selection as underscored by Trybula et al. (2015), we disclosed the parameters set for both Miscanthus and switchgrass.**
4) **We further investigated the differences in yield, water consumption, and especially WUE for both Miscanthus and switchgrass among different climate zones.**
5) **Except for existing models such as the LPJmL model, our enhanced H08 model provides new ways to evaluate the future impacts of human activities, such as irrigation, reservoir operation, and water withdrawal, on the large-scale establishment of bioenergy plantations.**

In summary, we firmly believe this study is interesting (as noted by SC1), well organized (as noted by RC1) and valuable for publication in Geoscientific Model Development.

[R2-M1] This ms considers only two lignocellulosic herbaceous energy crops, switchgrass and Miscanthus. These species are mainly considered as energy crops for temperate and continental climate zone. For the global simulations of second-generation herbaceous energy

crops, authors need to address additional species in the modeling like Napier grass, sugarcane/energycane which are suitable for growing in tropics (Surendra et al. 2018). Also, consideration of woody species like Eucalyptus in tropics and SRC in boreal is recommended in the analysis of yield comparison with LPJmL and/or ORCHIDEE-MICT-BIOENERGY models as they already simulate.

Response: Thanks for your suggestion. We fully understand the importance of bioenergy crops you kindly mentioned. Although important, we would like to keep focusing on two herbaceous energy crops due to the following three reasons. First, Miscanthus and switchgrass have been widely targeted in many previous studies, in particular, global and continental studies (such as Clifton-Brown et al., 2000, 2004; Beringer et al., 2011; Heck et al., 2018; Kang et al., 2014; Trybula et al., 2015). Second, systematic model-intercomparison of bioenergy crops have not been provided earlier. Third, as for global models, no model can explicitly estimate the yield of Miscanthus and switchgrass. For instance, LPJmL which is one of the leading models in this field, estimates C4 grass to represent Miscanthus or switchgrass. Other models (MISCANMOD, HPC-EPIC…) can either simulate Miscanthus or switchgrass. Our enhanced H08 model simultaneously simulated the yields for Miscanthus and switchgrass at the global scale which is the good advantage to earlier studies.

[R2-M2] Many studies show sensitivities on the yields, and requirement, even limited amount, of N and/or P fertilizer for these crops, particularly on switchgrass (e.g. Wullschlegeret al. 2010, Hong et al. 2014, Ashworth et al. 2016). SWAT model already contains implementations of the process of fertilizers applications. This is critical point.

Response: Thanks for your comment. We do agree with the reviewer that N and P affects the growth of the bioenergy crops. Nutrient dynamics is influenced by the complex site-specific soil conditions (soil type, temperature, wetness, carbon, etc.) which is still quite challenging to properly represent in global models. We have clearly noted this limitation in sections 3.6. We assume current yield refers to the ideal yield without constrains due to nutrients management. Similar assumption and limitation are seen in latest bioenergy potential studies

(Yamagata et al., 2018; Wu et al., 2019). Therefore, the results of this study can be interpreted as optimistic in the sense that N/P are sufficiently applied particularly in low-income countries and at the same time, it may not be the issue in middle or high-income countries. At least, historical validation shows without N/P consideration well reproduces (not biased).

[R2-M3] The simulated yields by the HO8 should be compared with simulation using SWAT model with the same climate forcing to validate the adopted implementations from the model described in the ms.

Response: Thanks for your comment. Although interesting, we haven't proceeded this since it is always hard to interpret the results of model-model comparison. Alternatively, we have provided the solid calibration/validation results (i.e. model-observation comparison) in Fig. 3 and Fig. 4. Moreover, we have made comparison with other three models as shown in Fig. 5. The result is comparable with other global models like HPC-EPIC and LPJml. Please note that a global application of SWAT model is quite laborious hence there are no available global bioenergy yield data from SWAT at present.

[R2-M4] The simulation uses climatology (1997-2016 average) for the input, however, to validate the model results with field observations, I would recommend using annual forcing data in the simulations for the corresponding years. In addition, only WFDEI forcing is used in the simulations. There is no supporting information on the rational of using the forcing date over other data set, like S14FD (Iizumi et al. 2017), CRU JRA. (Harris et al. 2019). At minimum, a revised manuscript must address the limitations.

Response: Thanks for your comment. First, we took your suggestion and conducted simulations with annual forcing meteorological data and revised the text and figures in the revised paper. The main results and conclusion did not change greatly. Regarding the selection of meteorological data, we also added the simulation results with meteorological driven from S14FD (Iizumi et al. 2017), as can be find in Fig. s2, the results are very similar with current driven form WFDEI. Therefore, we kept our results with driven from WFDEI data.

[R2-M5] It is critically needed to compared/validate the simulated yields using irrigation with field observations/experiments if data would be available.

Response: Thanks for your comment. We have added the result under irrigated condition with 10 available site observations as shown in Fig. s3. As can be seen, both good and bad result exist. However, it is difficult to judge the performance due to the limited number of observations. Moreover, we also added the comparison results with LPJml model under irrigation condition. The result is plotted in Fig. s4. It shows our simulation is consistent with LPJml. The correlation coefficient of the yield simulated by H08 and LPJmL in the scatter plot (Fig. s4) was 0.95. A t-test showed that the correlation was significant at the 0.01 level.

Minor comments:

[R2-S1] L16: Bauer et al. 2018 could be a "recent predictions".

Response: Thanks for recommending this paper. We added it in the revised manuscript.

[R2-S2] L61: Miguez et al. 2012 also considers both species.

Response: Thanks for recommending this paper. We added it in the revised manuscript.

[R2-S3] L62-64: Is it really few studies available? Nair et al. 2012 reviews and shows many models already available for the simulation

Response: First, thanks for recommending this review paper. In total, 14 models were introduced in the paper. As clearly documented in the paper, most of them are for field scale. Only two models called Agro-IBIS and LPJmL are for regional/global scale. Therefore, it means few simulations have been done at global stale, as we originally stated in Line 62-64.

[R2-S4] L154: I found no description on simulation algorithm of parameter ensemble in the supporting materials.

Response: We offered specific equations containing the parameters in the supplementary file. For example, base temperature (Tb) can be found in equation 1, the potential heat unit (Hun) can be found in equation 2, and so forth. Regarding the parameter ensemble in the simulation is summarized in Table 2. We conducted simulations with all combinations of each parameter as documented in Table 2.

[R2-S5] Fig.3: Is it possible to disaggregate the figure with each climate zones?

Response: Thanks for your comment, and we have identified the climate zone for each site and modified Fig. 3.

[R2-S6] Table s1, s2: I would recommend adding mean and SD of the observed yields in the tables.

Response: Thanks for your suggestion. We added the mean yield and the range of minimum and maximum yield in Table s1 and s2.

[R2-S7] L190: Too small sample size (N = 8).

Response: There are 15 countries' yield reported in MISCANMOD, originally, we made comparison for the 8 counties where yield simulated by H08 meet the requirement that higher than 10 Mg ha^{-1}yr^{-1}. In the revision, we used all the 15 samples in the comparison with the modification mentioned in response to [R2-S8] below.

[R2-S8] L192: I don't understand the reason of excluding that yield below 10 Mg ha^{-1} yr^{-1}.

Response: The reason is to make the comparison meaningful since MISCANMOD reported the results exceeding 10 Mg ha^{-1}yr^{-1} (Clifton-Brown et al., 2004). In the revision, we take more accurate method that consistent with MISCANMOD reports (Clifton-Brown et al., 2004) by excluding the area within a country if the yield is below 10 Mg ha^{-1}yr^{-1} before the country-average calculation. In addition, we also changed the calculation period from 1979-2016 to 1979-1990 to make it more consistent with MISCANMOD reports.

[R2-S9] L199: Does the result of Fig 5g change if the higher yield from Miscanthus or switchgrass calculated by H08 are used in the comparison?

Response: Thanks for your comment, we have made new figure (Fig. s5) with the separated yield of Miscanthus or switchgrass from H08 in supplementary file.

[R2-S10] L203: Is the discrepancy related to the modeling assumption of double cropping in the region? In practice, double or triple cropping can be done in the tropics for the herbaceous crops.

Response: Thanks for your suggestion. There are no assumptions of double cropping in those tropical zones in LPJml and H08.

[R2-S11] L215: I recommend comparing simulated results between SWAT and H08 using same forcing data.

Response: Thanks for your comment. As we responded in the [R2-M3], although interesting, let us drop this since model-model inter-comparison is hard to interpret.

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Thank you very much for your comments and suggestions.

Sincerely yours,

Zhipin Ai (on behalf of the co-authors)