**Report #1**

*P18 L26–30: It should be made clear that this is referring to CO2 fertilization, not application of fertilizer.*

Thank you very much for your comments. We changed this to read "$CO_2$ fertilization effect" in the revised manuscript.

**Report #2**

***Overall response***

*This is a revision of a previously reviewed manuscript. The authors have done a good job responding to the previous review, but some further clarifications and discussions need to be made, and some additional strengthening of the results would be helpful.*

1) *The novelty of this work is still understated. It is shown in figure 16b, but is not explained or highlighted as such. Similar plots of irrigation demand across these same sims should show further importance of incorporating climate/co2 into the land resource allocation, which is a primary new feature of miroc-integ-land that has very limited representation in global modeling.*
2) *please see comments below regarding further clarification and discussion.*

I sincerely appreciate that the reviewer carefully read the manuscript and gave us valuable comments and suggestions. According to your suggestions, we added a new figure, strengthened the discussion, and provided clarifications in the revised manuscript.

***Specific comments and suggestions:***

***Abstract***

*page 1, line 31: I think this should also be labelled as 'MIROC-INTEG-LAND' because this is what you are running here, with offline climate forcing.*

This term has been modified as suggested.

*page 2 line 2: You should expand on this statement. this is the real novelty of this work. The land allocation (and likely irrigation demand - do you have these outputs for figure 16?) is very different when the climate/co2 effects are included. this is what makes miroc-integ-land different from the current IAM scenario formulation.*

Thank you very much for this suggestion. We added the future changes in irrigation demand in Figure 16. The features of changes in land allocation and irrigation water demands are also discussed in Section 7, and their implications are discussed in Section 8.

***Model structure***

*It would be more clear if figure 1 included the names of the sub-models discussed here on pages 4* *and 5. The names can be in the figure or in the caption.*

The names of the models are explained in the caption of Figure 1.

***Sub models***

*page 7, lines 15-27: What exactly does HiGWMAT contribute to the crop growth model and the rest of the biogeochemical and biophysical system? Here you mention cropping period and growth, but growth is simulated separately by PRYSBI2. And in the next section you mention only water stress from HiGWMAT, and not cropping period. So, what does PRYSBI2 use? And are the biophysical fluxes in the land model updated after HiGWMAT determines water management/use?*

In MIROC-INTEG-LAND, the crop scheme used in HiGWMAT to estimate irrigation water is different from that used in PRYSBI2 to determine crop yields. The description on page 7 line 15, pointed out by the reviewer, is an explanation of the crop scheme that used to estimate the irrigation water. The cropping period used for estimating irrigation water in HiGWMAT is also different from the cropping period used for calculating crop yields in PRYSBI2. In PRYSBI2, the cropping period is determined by giving the planting and harvesting date based on the data of Sacks et al. (2010).

In the revised manuscript, it is explained that the description in Section 3.1.2 pertains to the cropping period used to estimate irrigation water in page 7, line 23. In addition, it is explained that the crop scheme used for estimating irrigation water (HiGWMAT) and the crop scheme used for obtaining crop yield (PRYSBI2) are different, in page 7, line 28. Furthermore, the cropping period of PRYSBI2 is explained in page 8 line 3.

For the explanation of cropping period in PRYSBI2, Section 3.2 PRYSBI2 and Appendix A.2 have been modified in the revised manuscript.

The role of HiGWMAT in MIROC-INTEG-LAND is to calculate human water management/use (3.1.2 Human water management scheme) and to calculate the energy and water budget on the land surface (3.1.1 MATSIRO land surface model). In HiGWMAT, the biophysical fluxes are updated after water management/use is determined. In the revised manuscript, this point is explained on page 6, line 23.

*page 8, lines 14-15: Does PRYSBI2 use only soil moisture from HiGWMAT, or does it use cropping period also? Later you state that it is just soil moisture and temperature.*

As explained above, the cropping periods of PRYSBI2 are different from that in HiGWMAT. In addition, PRYSBI2 uses soil moisture and temperature to calculate water stress and crop yields. This is explained in the revised manuscript on page 8, line 26.

***Numerical coupling***

*pages 10-11: Some of the important info wanted in the previous section is here, but the overall* *connections are not clear. For example, some of the variables passed between models are listed. Are these complete lists? It is still unclear which models are responsible for which overall land outputs. Does VISIT do all mass and energy land-atmosphere-flux outputs, or just the carbon and nitrogen cycles?*

All of the variables passed between sub-models are listed in Section 4. These are also explained in Figure 2. In order to explain which models are responsible for which overall land outputs, we added a description of the roles and outputs of each sub-model in Section 3.

*Figure 2 indicates that VISIT gets soil moisture and temperature from HiGWMAT, but the text states that there is no communication between these models.*

There is no communication between VISIT and HiGWMAT in this version of MIROC-INTEG-LAND. The connection in Figure 2 has been changed to reflect this.

*What appears to take place is that TeLMO first estimates land use, then HiGWMAT estimate water use, then PRYSBI2 estimates crop growth/yields, which then feedback to TeLMO for updated future land use estimates. When does VISIT get the TeLMO outputs? Before or after being informed by the water and crop models? And where are output water flux variables calculated? This flow needs to be completed and made clear.*

As described above, the roles of sub-models are explained more clearly in Section 3.1-3.4, in order to clarify the overall flow of the calculation. The outputs of energy water flux variables are calculated in HiGWMAT. This is also explained in Section 4 "Numerical procedure of model coupling", (2) HiGWMAT + PRYSBI2.

*Including a more detailed discussion of how the final surface model (VISIT) doesn't use the more detailed models to determine crop growth and water exchange and eventually land-atmosphere fluxes and carbon storage, but only the land use estimated from the more detailed models.*

VISIT receives only the output of land use change by TeLMO and is used to calculate the carbon and nitrogen cycle. For this reason, the energy and water balances are calculated independently within VISIT. The initial goal of model development was to use the energy and water budget calculated in HiGWMAT to calculate carbon and nitrogen cycles in VISIT, as the reviewer point out. However, as described in the original manuscript, the model structure of VISIT was very different from the model structure of HiGWMAT, so it was difficult to achieve this goal. Specifically, because HiGWMAT is based on MATSIRO being included in the climate model, it calculates the latitude-longitude loop in the time loop, but VISIT calculates the time loop in the latitude-longitude loop because there is no horizontal interaction in the model. We tried to rearrange the order of time and space loops in VISIT and combine them with HiGWMAT, but this was unsuccessful because VISIT is a huge program that computes various complicated processes. Consequently, we decided that VISIT should use only the TeLMO output to calculate the carbon-nitrogen cycle. In the current version of MIROC-INTEG-LAND, we first calculate the TeLMO-HiGWMAT-PRYSBI2 until 2100, and then perform VISIT calculation from the preindustrial period (including spin-up simulations) to the end of the 21st century using the TeLMO output; TeLMO is thus only used for the future period, and LUH data is used for other periods). VISIT has been used to perform a variety of calculations for ISIMIP etc. (e.g., Ito et al. 2020, Pronounced and unavoidable impacts of low-end global warming on northern high-latitude land ecosystems. *Environmental Research Letters*), and thus MIROC-INTEG-LAND uses the original VISIT structure to calculate the carbon and nitrogen cycle.

As described in Section 8, we are developing MIROC-INTEG-ES, in which the human activity models in this study are coupled to a state-of-the-art earth system model (MIROC-ES2L, Hajima et al. 2020). In MIROC-INTEG-ES, the inconsistency issue of the energy and water budget between VISIT and HiGWMAT has been resolved. In the revised manuscript, this is explained in Section 4, (4) VISIT.

***Experimental settings***

*What are the historical isimip forcings? figures 3 and 5 suggests that there are multiple realizations of the historical forcings.*

In ISIMIP, the historical and future climate simulations by five global climate models (GCMs) with bias correction are distributed as the forcing data. The methodology of bias correction is described in Hempel et al., (2013). These aspects are explained in the revised manuscript.

***Historical simulations***

*page 14, lines 6-7: If the model output and the reference data are on grids, why do you use another data set to aggregate to country scale? Is this just to get a ratio of physical area to harvested area to comparison with FAO?*

Yes, it is just to get a ratio of cropland/pasture/forest area to perform a comparison with FAO. This is explained in the revised manuscript.

*page 15, lines 21-25: if telmo matches aim regions, why are austaralia and russia so different from aim?*

TeLMO uses the food demand calculated by AIM/CGE (17 regions) and allocates the cropland area with a resolution of 0.5 degrees. On the other hand, the AIM/CGE results in Figure 7 are based on the 0.5-degree downscaled land use data using the AIM/CGE output (the methodology is described in Fujimori et al. 2017a). This is explained in the revised manuscript. The cropland area of Australia and Russia in Figure 7 differ among TeLMO and AIM/CGE, partly because the land allocation methods of TeLMO and AIM/CGE (Fujimori et al. 2017a) are different. The reason for the difference between TeLMO and AIM/CGE is discussed in the third paragraph of page 16. The reference Fujimori et al. 2017a is also added.

*page 15, lines 25-29: there are some large differences for forest in usa and australia. why is this? With the apparent country-level differences in pasture and forest it is not correct to state that telmo, aim and fao closely agree at the regional scale. This statement needs to be tempered and the differences acknowledged.*

The difference between TeLMO and FAO is likely because TeLMO refers to MODIS, but not to FAO. This is explained in the revised manuscript. The statement "Overall, TeLMO, AIM, and FAO closely agree at the regional scale." related to a previous version, which only included cropland area (Figure 7). That statement has been removed from the revised manuscript

***Future simulations and interaction of submodels***

*The isimip1 climate forcings do not match with the SSP scenarios you use. Not only were the climate forcings created from different IAMs, but the current SSP2 formulations are different than the socio-economic scenarios used for the RCPs from isimip. So you have inconsistencies in your forcing data. You should be using the CMIP5 SSP socio-economic drivers. This may not be a huge issue here because the atmosphere is not coupled to the land, which means that your climate drivers are somewhat independent of the land processes. If you cannot use the more closely matched driving data, you need to explain the mismatch and why it it exists and what impact it may have on your results. For example, while you can examine the effects of different RCP forcings on the land surface, these forcings are not necessarily consistent with the land processes, not only because the land model is not coupled to the atmosphere, but because the climate forcings do not match the land activities to begin with.*

Thank you very much for this suggestion. It is true that the socio-economic scenario in ISIMIP1 is not consistent with SSPs because it is based on the CMIP5 simulations. On the other hand, in ISIMIP3, the climate forcing will be based on the CMIP6 simulations. The ISIMIP3 forcing data has only recently been published. This is explained in Section 5, Experimental setting.

*page 16, line 6 and beyond: Figure 10, 10a, 10b, 10c*

*page 16, lines 16 and beyond: Your figures are out of order in referenced incorrectly. Ensure that they are numbers and referenced in order.*

Thank you very much for this correction. The numbers of the figures have been corrected in the revised manuscript.

*page 18 lines 20 forward: Do you have the irrigation results for these sims as well? figure 16b shows the real novelty of your development. The more outputs you can show that vary based on climate/co2 info and that matter for projecting human resource use, the better.*

Thank you very much for your suggestion. We added a new Figure 16c and discussed the impact of climate and CO2 fertilizer effects on irrigation demands in the last three paragraphs in Section 7.

***Implications and future research***

*So here you want to highlight how irrigation demand and cropland allocation change significantly if climate and/or CO2 effects are considered in this process. This interaction is the real novelty of miroc-integ-land. The IAMs are allocating land based on the green yield line in figure 16. But using miroc-integ-land, you get a very different allocation.*

We really appreciate the suggestion that we should highlight the novelty of MIROC-INTEG-LAND. In the revised manuscript, we described how MIROC-INTEG-LAND can be applied to investigate interactions in which climate change causes changes in crop yields, land use, terrestrial ecosystems, and water resources. This clarification appears in the first paragraph of Section 8.

***Tables and figures***

*Figure 8: Caption needs to be edited to state "ratio of pasture area to total area"*

*Figure 9: Caption needs to be edited to state "ratio of forest area to total area"*

Thank you very much. These captions have been corrected as suggested.