Dear Editor and Authors,

General comments

The authors conducted a series of simulations on global water scarcity using the GCAM model, an integrated assessment model with a global hydrological model. In this paper, they analyzed the impact of two types of climate mitigation policy on the global water availability and demand. They reported that some types of climate policy could considerably exacerbate global water scarcity.

The authors developed a new model coupling an integrated assessment model and a global hydrological model, and applied it for an interesting interdisciplinary research topic on the tradeoff between biomass energy production and water scarcity. Although this paper is novel, I have two major concerns for the current form of paper.

First, honestly speaking, I got an impression that extreme results have been derived from extreme assumptions in this study. The authors reported that the global total water withdrawal could reach as much as 25000 km^3 $year^{-1}$ (page 3395, line 8). This is more than 60% of the current global total annual river discharge, and as far as I know and as shown in Figure 6, the number might be the largest projection ever reported. The authors mainly attributed this to the increase in irrigation for crops and biomass triggered by carbon tax. Under this (or similar) condition, according to Wise et al. (2009), more than 50% of global land would be used for bioenergy crop production, and unmanaged forest completely disappear in the latter half of the 21^{st} century. The rationale and feasibility of these assumptions should be mentioned in text. To begin with, why was this extreme carbon tax scenario chosen here? What were the key mechanisms of areal expansion of irrigated area? The authors assumed that water is unlimitedly available from "non-renewable groundwater" anytime and anywhere in this study. Didn't this lead to unrealistically high pressure toward irrigation expansion? Unfortunately, the answers to these questions are little described in this paper. Second, the structure of paper has much room for improvement. Above all, the paper is too long. Now it includes much redundant information (see below). Moreover, the connection between Part 1 and Part 2 is difficult to find: the results of Part 2 are mainly related to the increase of water demand, but Part 1 only explains the model for water availability.

Specific comments

Page 3384, Line 15-17, "*The decreasing trend with UCT policy stringency is due to substitution from more water-intensive to less water-intensive choices in food and energy production*": As far as I understood, water is unlimitedly available in this study. Then, how less water-intensive options were chosen in this study?

Page 3388, Section 2: This section completely overlaps with Part 1. I think the whole section can be removed.

Page 3388, line 19-20, "*additional supply is assumed to come from non-renewable groundwater*": The assumption here is same as Wise et al. (2009). Then, what is the role of the water availability module of GCAM in this study? I got an impression that the water availability module of GCAM was not very efficiently used in this study.

Page 3391, Line 14-24, "*Wise et al. (2009) uses…*": The simulation of Wise et al. (2009) is interesting but their assumption and consequence are quite extreme (e.g. more than 50% of global land is used for bioenergy crop production, and unmanaged forest completely disappear in the latter half of the 21st century). Why was their study specifically revisited here?

Page 3396, Line 1, "*biomass water withdrawals increases … to a range of 1782-13212* $km^3\ yr^{-1}$": At least to me, the results are too extreme (e.g. more than three times of the current global total water withdrawal is used only for biomass water withdrawal) and I am not fully convinced that the results are meaningful. Here more detailed background of the number should be disclosed. What is the total area of biomass cropland? What is the fraction of irrigated area? How was the areal expansion of irrigation modeled? How it is spatially distributed? What type of crop was planted? If all the biomass energy was produced by rainfed agriculture, what would be the results? This would require additional land but no water demand. In reality, both water and potential area for new irrigation projects are limited (e.g. Bruinsma, 2003).

Page 3397, Line 5-29 "*Figure 8*": Information of Figure 8 is largely overlapping with Figure 7. I think Figure 8 and this part can be removed.

Page 3398, Line 10-18 "*Figure 10*": Information of Figure 10 is largely overlapping with Figure 9. I think Figure 10 and this part can be removed.

Page 3402, line 23-25 "*Recall that global water withdrawals range between 8843-9276*km^3yr^{-1} *in 2050…*": How much of water should be taken from "non-renewable groundwater" for each year? What is the cumulative volume throughout the 21st century?

References

Bruinsma, J.: World agriculture: towards 2015/2030 An FAO perspective, EarthScan, 2003.