Anonymous Referee #4

The study aims to describe links between water, vegetation and carbon dynamics using a global perspective. According to page 4442, lines 12-20, the main focus of this article is on: - the current and potential future water limitation of terrestrial vegetation (natural and agricultural, rainfed and irrigated), as controlled by global climate and its anticipated future changes; - the potential of water management options to increase crop production by reducing this water limitation to some extent; - the effect of human land cover/land use changes and water withdrawals on freshwater flows and resources. The paper represents a synthesis of research findings generated by applying the global dynamic vegetation model LPJmL. These findings are compared to outcomes of other studies and current research gaps are identified. I completely agree with the other reviewers who already indicated that the topic of the article is very relevant and interesting. I also agree that the manuscript can still be improved by some modifications and clarifications. There are many good points mentioned in the three referee reports published before. I will try to complement but not to repeat these points here.

Thanks for your comments. The points raised by the other referees will be addressed as indicated above.

1.) The paper does not really fit to common article types. It's not a typical research article because it mainly builds on findings already published before. It's also not a typical review because it has a strong focus on the results of different versions of LPJ or LPJmL. I don't see this negative because the author has been heavily involved in the development of LPJmL and therefore in a good position to synthesize the findings of previous studies but I think that the author should explain the motivation for this setup more in detail. Is the major objective to compare LPJmL with other models or approaches? Is the model in particular useful to address the three research questions mentioned before?

Indeed, the paper is designed to be a review paper but using selected results from the LPJmL DGVM (which has the unique feature of simulating water-vegetation interactions at global scale for both natural and agricultural plants and which has been used for studying the topics discussed here). The purpose is not to provide an assessment of the quality of this model (compared to other models), but some perspectives for improving such models will be provided in the revision, in response to other referees' comments.

2.) There are some constraints and limitations that should be discussed more explicitly in the article. LPJmL is a vegetation model which, in its current version, cannot represent feedback mechanisms of land use and land management on climate and weather conditions. There are many articles showing that land cover and land management (in particular irrigation) have an impact on regional climate (temperature, precipitation, humidity). Freshwater (except fossil groundwater) is a renewable resource, therefore it cannot get lost. Consequently it is more important to analyze spatio-temporal patterns of water availability, water requirement and of flows between compartments rather than computing annual (global) flow rates. With regard to this aspect the one-way link between climate and vegetation in LPJmL is certainly a shortcoming, in particular to address the third research question (the effect of human land cover/land use changes and water withdrawals on freshwater flows and resources). There are some GCM's or RCM's that can better represent the interplay between vegetation and climate/weather and should be mentioned therefore.

This is certainly right, and it has only been briefly mentioned in the paper. The revision will address the issue of land surface-atmosphere coupling in some more detail.

In addition to model limitations, there are also major limitations in data availability for global studies. In particular to address research question 2 (the potential of water management options to increase crop production by reducing this water limitation to some extent) it is

important to not only know water management but also crop management in general. The impact of yield limiting and yield reducing factors (as mentioned already by reviewer 1) is difficult to assess at global scale because: - crop areas, yields, production are only available at the required resolution for the period around year 2000, - spatial data indicating crop specific use of fertilizers or pesticides are not available at global scale, - spatial data on the occurrence of pests or diseases are not available, - spatial data on typical crop rotations are missing, - information about use of different cultivars, their potential productivity and their sensitivity to yield limiting and yield reducing factors is missing, - information on sowing and harvest dates is very limited at global scale. This means, that very little spatial information is available for the factors that have the largest impact on crop yields and resource productivity and that global models have to use a lot of assumptions instead of it. The same is true for the impact of technological change which is at best represented by using time series at country level provided by FAO and other international organizations. Uncertainties arising from the poor data availability and from the use of basic assumptions are described in the original research articles cited in this review but need to be summarized here as well. Comparing results of different models is not a substitute because global models often use the same assumptions so that differences between models often do not reflect real uncertainties.

I agree with this perspective. These issues will be discussed in the revision, though only briefly as they are somewhat beyond the water-vegetation links on which the paper focuses.