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Interactive comment on "Hydrological impacts of global land cover change and human water use" *by* Joyce H. C. Bosmans

Anonymous Referee #1

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The paper describes a global assessment of hydrological impacts of land cover change and human water use for the period 1850-2000 and fits therefore well to the scope of the journal. The manuscript is well written and interesting; the figures shown in the manuscript are of good quality. Quantifying the effects of land cover change and water use on the hydrological cycle for such a long period is challenging and previous estimates varied considerably, depending on input data, models and assumptions used. Therefore, more research is needed to reduce these uncertainties. However, I think that a major revision is required before the manuscript may be considered for publication in HESS. My major points of criticism are:

General comments: 1) The authors quantify and compare the effects of land cover change and water consumption on evapotranspiration and river discharge. However, they assume that the third term in the water balance, the precipitation term, is not

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affected by the changes in land cover and water use (at least there is no attempt to analyze changes in precipitation). This is a strong assumption that needs at least some discussion, because the authors present here a spatial analysis. There is growing evidence in the literature that both, land cover change and water use, modify precipitation patterns over large regions (see for example Pei et al., 2016 on the effect of irrigation on summer precipitation in the US). When irrigation results in increased ET, increased ET results in increased precipitation, and increased precipitation results in increased runoff. Consequently, the net effect of irrigation on river discharge may be much smaller than the results suggested by the authors. So the key question is certainly where water use and land cover change are taking place and in which region this will cause changes in precipitation (within the same watershed, outside of it but in another watershed or over the sea outside terrestrial surface). Answering this question is only possible by coupling a hydrological model with an atmospheric circulation model. This might be out of scope of the present analysis but the consequences of ignoring feedback mechanisms by changed precipitation patterns requires at least discussion.

2) One basic result of the study is that the effect of human water use on actual evapotranspiration is smaller than the effect of land cover change (page 11, line 6). However, the increase of ET by irrigation estimated by the authors seems to be very low compared to other studies. According to the present study, global ET is increased by irrigation by 377 km3 yr-1 (page 11, line 7) while other studies reported a much larger increase in ET by irrigation (for example, > 1000 km3 yr-1 between 1900 and 2005 according to Kummu et al., 2016). Why is that? Assuming that the uncertainty in additional ET created by irrigation is that large: how would this uncertainty then affect the basic conclusions drawn by the authors?

3) The authors explicitly pointed out that an analysis and discussion of the uncertainties involved in their estimates was not focus of the present analysis (page 14, lines 30-32). Nevertheless, these uncertainties exist and should be discussed. It is complex enough to simulate changes in ET on cropland because data for irrigated/rainfed crops and

the distinction between paddy and upland crops are available for recent years only, in addition simulation of ET for the period outside the cropping season requires many assumptions. Even more complex and extremely difficult is it to estimate changes in ET caused by the use of ecosystems as pasture. There are many different types of pasture characterized by distinct species composition, different proportion of woody biomass and different stocking densities. There are very intensive types of pasture with properties very similar to cropped surfaces and extensive pasture systems that hardly differ from natural vegetation. It remains completely unclear how the authors reflected this complexity in the parameterization of their model to estimate realistic changes in ET caused by the conversion of natural vegetation to pasture. In addition, there are large uncertainties about the historical extent of pasture. Currently available data sets differ considerably in their estimates. The authors mention these uncertainties in section 4.2 but it remains unclear how much the basic results of the study are impacted by these uncertainties. How robust are the results of the study? More description and discussion is needed.

4) The text section is often difficult to read because it contains too many numbers and reads to technical (e.g. section 4.1; section 3.2). I recommend to report the general findings in the text section and detailed results in tables. It may also help to develop a figure presenting the main results of the study (changes in terrestrial ET and discharge by water use and land cover change at global scale).

Minor comments: Abstract: Please report more in detail how the present study adds to a better understanding of the impact of lands cover change and water use on terrestrial hydrology. What is reported in the second part of the abstract represents more the state of knowledge but not new findings and conclusions from the present analysis.

Page 2, lines 25-29: This sentence is hard to understand. Please simplify.

Page 3, lines 5-9: Please simplify. Not nice to have brackets in brackets . . . .

Page 3, lines 28-30: ERA-Interim and CRU data often differ considerably, in particular

for precipitation and number of wet days. Is this not a problem when combining these two products?

Page 3, line 33: More description is needed how the different land cover types were parameterized to account for different types of pasture vegetation and crops. For example, the rooting depth may vary considerably even within the 6 major land cover classes used by the authors.

Page 6, section 2.3: How were reservoirs treated in LC1850 and LC2000?

Page 11, lines 6-7: “as evapotranspiration is only increased over irrigated areas”. => This is an assumption made by the authors, however, in reality ET has also changed considerably in rainfed crops due to land use modification.

References: Kummu, M., Guillaume, J.H.A., de Moel, H., Eisner, S., Florke, M., Porkka, M., Siebert, S., Veldkamp, T.I.E. and Ward, P.J., 2016. The world’s road to water scarcity: shortage and stress in the 20th century and pathways towards sustainability. Scientific Reports, 6, 38495.

Pei, L.S., Moore, N., Zhong, S.Y., Kendall, A.D., Gao, Z.Q. and Hyndman, D.W., 2016. Effects of Irrigation on Summer Precipitation over the United States. Journal of Climate, 29, 3541-3558.

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