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Hydrology and Earth System Sciences Discussions

Interactive comment on "Detecting the long-term impacts from climate variability and increasing water consumption on runoff in the Krishna river basin (India)" *by* L. M. Bouwer et al.

Anonymous Referee #2

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Manuscript entitled "Detecting the long-term impacts from climate variability and increasing water consumption on runoff in the Krishna river basin (India)" by L.M. Bouwer, J.C.J.H. Aerts, P. Droogers and A.J. Dolman.

General comments:

This paper considers the very important issue of the effect of man-made hydrological development on the river runoff at the basin scale. This effect is studied over a 100-year period with both the STREAM water balance model and long term RivDis

and CRU observations. Different simulations are performed in order to separate the effect of climate variability from the effect of human water consumption. The considered region (Krishna river in India) is particularly relevant for such a study. It is characterized by very strong human developments (water reservoirs) to support irrigation and industry.
The paper is well organized and well written. But before its publication in HESS, I suggest to take into account the comments indicated below.

Specific comments:

1) The impact of increasing water consumption is addressed through the increase of reservoir capacity. 87% of the global water consumption is for irrigation purpose. Irrigation affects the partition of energy between LE and H and modifies the water budget and river runoff. Water reservoirs are the main infrastructure that allow to control the timing of water withdrawn in order to satisfy irrigation requirements. They make possible a time lag between irrigation and water withdrawn. Accordingly, water reservoir do not directly impact on the annual mean water budget, but they may affect the seasonal effect of irrigation on river runoff.
In order to simulate the impact of water consumption, it is necessary to account for (i) irrigation which is the main process that affect the water budget, (ii) related infrastructure that make irrigation feasible and affects the annual cycle of river runoff. It is not clear in this paper how irrigation is taken into account. This is a major point that must be addressed to improve the clarity of the scientific objectives of the paper.

2) To improve the quality of the paper it is necessary to provide more references about the state of the art in irrigation-climate interactions studies. The three reference below are relevant to be cited in the introduction (and used as reference when processes are analyzed) in your paper:

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- Döll, P., and S. Siebert, Global modeling of irrigation water requirements, Water Resour. Res., 38(4), 8.1-8.10, 2002
- De Rosnay, P., J. Polcher, K. Laval and M. Sabre Integrated parameterization of irrigation in the land surface model ORCHIDEE. Validation over Indian Peninsula, Geophys. Reas. Letter, 30(19), 2003
- Haddeland, I., D. Lettenmaier and T. Skaugen Effects of irrigation on the water and energy balances of the Colorado and Mekong river basins, J. of Hydromet., 324(1-4), 210-223, 2006

This is particularly important to explain the relevance of your paper compared to these previous studies to study the impact of water consumption on river runoff.

3) I wonder if the term 'runoff' is appropriate to indicate the 'river runoff' in this study. It may be confusing for the reader with the 'soil water runoff'. The effect of water consumption are mainly related to irrigation water use. And irrigation has an opposite effect on soil runoff (increase) and river runoff (decrease). The paper is interesting for a large community in hydrology and climate (for which 'runoff' is soil over flow) and even if it is explained, the term 'runoff' used in the paper is not enough accurate. To improve the clarity of the paper and to avoid confusing concerning this point I suggest to write 'river runoff' instead of 'runoff' everywhere in the paper. This is particularly the case in section 4.3 where you show a negative trend in **river** runoff due to an increase of water consumption.

4) Section 4.4 last paragraph. The authors show a clear trend on the observed river runoff after 1960. Compared to the model results (which represent the case with no human impact), the observed river runoff is lower during monsoon season (June-Nov) and higher after the monsoon (Dec-May). The authors explain the June-November

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river runoff decrease by a large water consumption for reservoir filling during the monsoon. And they explain the river runoff increase by irrigation from December to May. This interpretation is not clear enough to be in agreement with the irrigation data provided by FAO. Irrigation over India reaches its maximum in September-October and there is only very few irrigation from December to May. Döll and Siebert also provide estimates of irrigation at the monthly scale in the data set they provide. Informations are also provided in Haddeland et al., 2006 and de Rosnay et al., 2003.
Here again (see point2), the authors should refer to previous studies in order to provide appropriate physical interpretation of the processes. Large irrigation during monsoon was shown to have a large negative impact on river runoff in previous studies. But previous studies was not able to account for reservoir filling. What is the relative role of net irrigation and reservoir filling in the river runoff decrease during the monsoon ? This is a key point that this paper could address. Field irrigation that occurs in May-Nov is expected to lead to an increase in the soil runoff. Can the observed river runoff increase in Dec-May be explained by the time delay between soil runoff and river runoff ?

5) Section 5. Modification where performed in the model to simulate the human impact on the river runoff. Human impact is taken into account through the increase of reservoirs capacity. The link between equation 2-3 and equations provided in Appendix A and in particular ET0, is not clear to me. More explanations must be provided to improve the clarity of the paper. This is critical to understand the last part of section 5 where the additional evaporation 'for irrigation and hydro-power purpose' is computed. Is this additional evaporation due to irrigation (including evaporation form reservoirs and evapotranspiration from field) or is it additional evaporation from reservoirs only ?

Page 7 top lines 12 to 16. As indicated in the paper, increase in reservoir capacity does not result in a proportionate reduction in river runoff: there are many physical

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processes between soil reservoir capacity and river runoff and most of them are affected by non-linearities. When you correct the reservoir capacity in order to improve the simulation of river runoff, the damping factor accumulates and replaces all the physical processes that are not taken into account in the model. Please clarify this point.

Technical correction:

Page 1 line 24, remove 'drinking'. This represents a negligible fraction of water consumption.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 3, 1249, 2006.