Hydrol. Earth Syst. Sci. Discuss., 8, C4496–C4501, 2011
www.hydrol-earth-syst-sci-discuss.net/8/C4496/2011/

Hydrology and Earth System Sciences Discussions

Interactive comment on "Hydrological responses to climate change conditioned by historic alterations of land-use and water-use" *by* J. Jarsjö et al.

Anonymous Referee #2

Received and published: 19 October 2011

general comments

The study describes the implementation of a water balance model for the Aral sea basin, in order to simulate the impact of future climate change, and to compare this with the impact of water extraction for irrigation on runoff.

The results are potentially very interesting, as they shed light on the relative importance of different disturbances of the water cycle, which may define both research priorities and water management strategies. However, in its current state, I identify several problems with the implementation of the modelling and the interpretation of the results. The

most important ones are:

- The study seems to rely very much on earlier efforts of modelling the Aral sea basin. I support the desire to be concise and avoid repetition of work that is already published. However, enough information should be provided to allow interpretation of the results and scrutinization of the authors' claims, which in my opinion is currently not the case. For instance, one of the conclusions of the paper is that their offline modelling is an improvement over the online implementation of land-surface processes in GCMs, but this is not clear. At least some information should be given on how land-use and land-cover information is used in the model, how irrigation is dealt with (e.g., efficiency, separation of recharge and evapotranspiration fluxes), what, if any, observation data were used to calibrate the model. Also, more details on the model performance should be given, if only to be able to compare the model's uncertainty with the uncertainty of the GCM projections.

- The paper concludes that it is better to use the model ensemble mean rather than results based on one single GCM model, based on the fact that the ensemble mean tends to be closer to the CRU reanalysis data than individual models. Although this is a sensible approach, it should be noted that:

* the CRU reanalysis data may not be an independent source of information, especially for the AR4 models. Given that the CRU data were available during the implementation of the models for AR4, climate modellers may have aimed at improving agreements between the reanalysis data and the simulations. This may also be a reason behind convergence of the AR4 ensemble compared to TAR.

* It may be erroneous to extrapolate agreement between historic observations and simulations towards predictive capacity in the future, especially when anomalies are used (see e.g., D. A. Stainforth, T. E. Downing, R. Washington, A. Lopez, and M. New. Issues in the interpretation of climate model ensembles to inform decisions. Philosophical Transactions of the Royal Society A, 365:2163–2177, 2007).

HESSD

8, C4496–C4501, 2011

* An advantage of implementing a model ensemble is not only the possibility of calculating a mean (or median) but also the spread of the ensemble as a measure of uncertainty. This is currently only superficially discussed in the paper.

- Although the paper claims to deal with interactions between climate change and water use, in fact both processes are dealt with separately. All water use is held constant for the future, and the impact of climate change without water use is compared to that without water use. This is a useful first approximation because of the non-linearities in the relation between water extraction and evapotranspiration, but it is a very coarse approximation. Water use is very likely to change in the future, either because of a higher demand, or because of limitations in supply. The fact that some scenarios result in a negative runoff (Fig. 3), which I interpret as groundwater depletion, highlights that water shortages will be important in the near future. This should be discussed in more detail.

specific comments

7596/18: define R here (which is where it is used for the first time). However, it is preferable to use the full word throughout the paper for readability.

7598/1: what are "long-term change performances"?

7597/28 - 7598/12: What is the relevance of this discussion about short-term versus long-term modelling?

7598/24: different change pressures -> different types of change

7598/13 - 29: this paragraph is vague and little to the point. What you want to argue is basically, that if one is to determine the impact of changes in land cover and water use on river flow, it is important to close the water balance?

7598/27: runoff: Are you able to separate river flow from groundwater flows. Does the model deal with this?

HESSD

8, C4496–C4501, 2011

7599/15: Do you really resolve interaction? Interaction would mean either impact of land-use change on climate, or impact on climate change on water extraction and/or land-use. It seem that you treat both separately (i.e. keeping one constant while varying the other) and compare the relative changes.

7599/22: main uncertainties: basically only one type of uncertainty is dealt with, which is the uncertainty in the climate projections. There is no uncertainty analysis of the hydrological model at all.

7600/4 & 5: the text would be more fluent if you use precipitation and runoff instad of P and R throughout the text.

7601/7-11: Here a case is made for the direct use of GCM outputs. The size of the Aral sea basin may indeed reduce the bias in the total precipitation flux over the basin as represented by the GCMs, but much depends on how the water balance model deals with the spatial distribution of precipitation, as well as precipitation intensity and duration. Each of these characteristics may have an important impact on model behaviour, for instance whether precipitation evaporates or runs of into the drainage network.

7601/ section 3.1: some equations of the main algorithms would be useful here.

7602/1-15: Even with the presented references, a more detailed description of the hydrological model is necessary. Is it correct that that the implemented model does not do any time stepping, but only calculate the water balance over a 30 year period? If so, land-use is necessarily held constant over the entire time period. Is this realistic for the past? What land-use discretisation was used? If the Langbein formula was used, I presume that no vegetation properties incorporated? How was irrigation accounted for?

7602/21: fully consistent with effects of historical, multi-decadal land-use and water-use driven changes: this is a bold statement. Even though the model performance is probably fully presented the given reference, it would be good to provide more de-

HESSD

8, C4496–C4501, 2011

tails, such as the goodness of fit and the number of observations that the model was compared (calibrated?) to.

7603/1-8: Both Langbein and Thronthwaite are known to be prone to large bias. Have any studies been done to compare these methods with more recent methods such as Penman Monteith? At least for the historical period (were data about humidity, radiation and others are available) this should be possible.

7603/15: keeping irrigated area stable may be consistent with the impossibility to expand irrigation, but it may be inconsistent a forced decrease of irrigation because of a lack of water under future drying scenarios.

7603/29 - 7604/2: the use of calibrated and uncalibrated is wrong here. No calibration was done. It would be more correct to distinguish between the two methods as bias-corrected and not bias corrected. Also, where absolute or relative anomalies used?

7604/21: the corresponding ensemble mean value: is this for TAR or AR4 or both?

7604/25: what is the TAR model ensemble average P?

7605/13 and further: The results would be much easier to interpret if they were expressed as mm/year instead of km3/year

7605/25-28: I disagree with this conclusion, especially since the reanalysis data and the model simulations may not be independent (see higher). It is much more useful to look at the ensemble spread.

7606/1: Given that the model structures are not independent, the standard deviation may not be the best indicator of spread. I suggest you use either the total prediction envelope, or add the models outside the standard deviation as points in Figure 2 (see also Mote, P., L. Brekke, P. B. Duffy, and E. Maurer (2011), Guidelines for constructing climate scenarios, Eos Trans. AGU, 92(31), doi:10.1029/2011EO310001.)

7606/13-16: this discussion seems to start from the premise that the ensemble mean

HESSD

8, C4496–C4501, 2011

is the correct prediction which is not true. If some models do predict a positive change in runoff, then there is a non-negligible chance that future runoff will indeed increase.

7606/20-7607/3: This discussion assumes that the CRU data set is correct which is unlikely to be the case.

7609/11 - 14: This is not true. In fact, most hydrological models incorporate land-surface schemes that are much more complex than the model implemented in this study. The model itself is perhaps implemented at higher resolution, but it is unclear whether this yields any improvement, because (1) precipitation is not disaggregated, and (2) it is unclear how the model takes benefit from higher resolution land-cover maps. For instance, it seems that the evapotranspiration routine does not use information about land cover. One advantage of the offline approach would be the ability to incorporate interactions with water extraction for irrigation. However, in the current setup, such interaction is not dealt with. Rather, both processes (water use impacts and climate change impacts) are modelled independently.

Fig. 3: On what kind of observations are the observed runoff data based?

Fig. 3: please also indicate the spread of the GCM model ensemble for the projections

Fig. 3: are the groundwater water depletions projected by the uncalibrated models realistic? Would it not be more likely that irrigation will decrease because of a lack of water? Again expressing the runoff in mm/year rather than km3/year would make this easier to interpret.

Fig. 4: the sketches on the right-hand side are unclear. What do the bended shapes represent? Do the different colours have any meaning? It would probably be much clearer to show the values as bar charts.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 8, 7595, 2011.