Hydrol. Earth Syst. Sci. Discuss.,
doi:10.5194/hess-2015-502-AC2, 2016

Hydrology and Earth System Sciences
Open Access
Discussions

Interactive comment on "Large-scale water scarcity assessment under global changes: insights from a hydroeconomic framework" *by* N. Neverre et al.

N. Neverre et al.

neverre@centre-cired.fr

Received and published: 30 June 2016

Please find below our replies to Anonymous Referee #2 comments. Original comments from the referee are in quotes and our replies follow (>).

—

1. Estimating water availability:

"Some more details should be presented here. How good is the climate model in predicting present-day runoff in the region? Is 2050 runoff taken directly from the model or do you use some kind of change factor methodology? What is your assessment of the uncertainty of 2050 water availability? In order to compute future irrigation demands,

do you directly use the simulated precipitation from the climate model? How good is the climate model in terms of predicting present precipitation? It would be good to briefly revise the main assumptions, limitations and sources of uncertainty and then refer to Portoghese et al. 2013 for details."

> i) Climate model: The climate model used is pertinent in the context of an application of our framework to the Mediterranean because it uses a stretched-grid global climate model zoomed on the Mediterranean coupled with a high-resolution oceanic model of the Mediterranean (Dubois et al., 2012). We do not have much information on the model biases. From our interactions with the model developers, we gathered that there was no particular bias identified, but the model may underestimate extreme events (Dubois et al., 2012).

Since the climate model is a coupled model it is not possible to evaluate the modelled runoff results by using historical precipitation and temperature as inputs (the model uses radiative forcing as input, the rest is endogenous). To our knowledge, there was no experiment of using the model only for runoff computation, decoupled from the rest. It is not possible to compare the model's results to historical times series, it can only be compared to statistics.

The only published data source we have on outflows from Algerian reservoirs is Pérennès (1993), for reservoirs built before 1920. These reservoirs may have been modified since. What we can do is use this data to check that the modelled unregulated flows to these reservoirs are higher than the regulated outflows reported in Pérennès (1993) data.

> ii) Outputs used: Yes runoff outputs of the model are directly used to compute runoff to the reservoir. To compute irrigation demands, we use a linear formula to determine the share of precipitation that runs off from total precipitation (following the methodology used in Döll, 2002). This information will be added to the manuscript (section 2.2.1), and we will also reference another paper which focuses more on irrigation de-

mand, that was previously under revision but is now published (Neverre and Dumas, 2016). We will also specify that, in the present paper, irrigation needs are computed considering that the length of the growing seasons remains unchanged under future climatic conditions.

> iii) Limitations and sources of uncertainty: We will add a paragraph to discuss this. Of course relying on only one climate model, under only one future climate scenario is a serious limitation. We feel that the present paper is not the place to perform an uncertainty analysis. It would be necessary to compare several models and forcing scenarios. It is not possible to add such an analysis to the present paper; it would require a separate paper. What we can do here is discuss the uncertainty associated with the use of one model and one climate scenario. We will add this discussion in the revised manuscript.

We will also state more clearly that the focus of the paper is a demonstration of what can be done with the hydroeconomic framework. It will have to be run under different scenarios and further evaluated. This first application makes it possible to test the assumption that reservoir operation rules based on economic criteria will become more relevant to mitigate water scarcity under global changes than they are under historical conditions. The first results presented in the present paper invalidate this assumption. We obtain heterogeneous results between basins, and in some basins the assumption is invalidated. Cf. section 5.2: "For some basins (9, 33, 1170, 1189, 1190, 1191 and 1192), the positive impact of prioritization is more pronounced under past conditions than under future conditions." Running different scenarios would inform on the robustness of these findings, but we can already show a first invalidation: the benefits of operating rules based on economic criteria are not unequivocally increased with global changes.

—

2. Agricultural yield and water availability:

"Figure 2 shows a piecewise linear relationship. Does this relationship apply at the time scale of the entire growing season or for individual growth stages? [...] is there a constant water value throughout the season, independent of irrigation history?"

> Yes the piecewise linear relationship applies for the entire growing season. And there is a constant water value throughout the season. It is an average value that is calculated over the whole climatology (50 years) of the considered time period (historical or future period).

"Irrigation agriculture presents the well-known problem of "delayed yields", i.e. the yield is a function of shortages occurring in all growth stages and shortages in one stage cannot be offset by surpluses in the next stage."

> Irrigation needs are computed at a monthly time step, so there is no possibility of offsetting past shortages by surpluses in the next month: each month, water is allocated to the irrigation sector up to the crops needs; there are no irrigation surpluses.

> We could take into account the different phases of the growing season when estimating the loss due to irrigation water shortages over the year, but there would then be a discrepancy as the economic value we would then obtain would differ from the value that is used for the monthly allocation decisions. To take into account irrigation history, it would be necessary to have a dynamic model, in which water value for the crop would be re-evaluated each month depending on the water allocated during the previous months.

We do not try to capture this variability of the value within the season. We think that we do not need this level of precision here. The results we present in the paper are average results for the whole climatology (50 years). What we want is to have an evaluation of the average opportunity cost for irrigation, to be able to consider tradeoffs between different water use sectors. When there is not enough water to satisfy irrigation needs, there is not only a loss for the irrigated culture, but implicitly there is a change of the cultural system from irrigated to rainfed. This switch is not modelled explicitly on a yearly basis, rather the average difference of value gives an idea of the expected water value for the irrigation sector.

This will be made clearer in the manuscript, and we will reference another paper which focuses more on irrigation demand projection and valuation, that was previously under revision but is now published (Neverre and Dumas, 2016).

—

3. Network reconstruction:

“I do understand the rationale behind the chosen approach, i.e. generating the network topology purely from the elevation model. It is attractive because you can generate a model without detailed knowledge about the system, but it is also dangerous, because many links that are outlined by the algorithm may not be there in physical reality and others, that the algorithm cannot find (e.g. South to North Water transfer in China...) may be present in reality. However, network topology to a large extent determines spatial and temporal trade-offs. I believe the authors should present more information to validate the network construction algorithm and to elucidate its limitations.”

> i) Water transfers: Indeed, this type of link between reservoirs cannot be generated automatically in the model. However, these links are infrequent enough to be added manually when they are known. The model is not yet able to handle two interconnected basins, since it cannot handle several downstream systems yet. This feature would have to be added to the framework. It will be the subject of future developments of the framework. Links between reservoirs and demands located in different basins are already considered in the framework, as explained in the paper.

> ii) Erroneous associations: Indeed, the algorithm may find links that are not present in reality. The validation of the network reconstruction in Algeria showed that such errors exist (Cf. Appendix F). This validation experiment on Algeria was the subject of a whole paper, which is currently under revision (Nassopoulos and Dumas, under

revision). The main results that were relevant for the present paper are presented in the Appendix F. We will further discuss this issue in the main text.

“If this is used on a new area, how can one establish trust in the outlined network and how can the network be validated?”

> iii) Application to another area: To validate the network reconstruction, it is necessary to have knowledge of real links, to compare them with the links that result from the algorithm. If an evaluation results in a change of the modelling, it could lead to general improvement in matching with observed data. However, in a general way, a validation cannot be transposed. Each time a model is applied to a new area, it is not possible to know a priori how valid it will be.

—

4. Genetic Algorithm:

“It would be good to report more details on the GA setup: Which are the decision variables (how many are there)? Is it the alpha and beta parameters? What was the computational effort, how was convergence etc.”

> Yes, the decision parameters are the alpha and beta parameters. There is one alpha parameter for each tree node (i.e. 18 alpha parameters in total for basin #1186, or 4 for basin #1175 for instance), and one beta parameter for each parallel branch (i.e. 6 beta parameters in total for basin #1186, or 1 for basin 1175). We used a population size of 100 and 20 generations. We tried different numbers of runs and generations, and chose the best trade-off between computation time and convergence. We will add a paragraph in the manuscript to give more information about this.

—

5. Tree traversals:

“Section 4.3.4 on tree traversal and also the corresponding appendix D are very short.

A minimum amount of information should be given enabling the reader to under- stand how this works. Figs 5 and 6 do not communicate very well, captions need to be expanded."

> The text describing tree traversals and the captions of the associated figures will be expanded.

—

6. Uncertainty:

"As with all studies using complex modelling chains, uncertainty assessment is a real challenge here. How robust are the headline results reported in tables 2-4? Which of the reported differences are statistically different from zero? What is the largest contribution to uncertainty – future climate or economic valuation? No attempt is made in the paper to address the uncertainty of results. I know it is difficult, but authors must at least discuss the issue qualitatively, quantitative estimates would be much better."

> We will add some discussion in the manuscript (Cf. also comment 1.).

> We will add a qualitative/semi quantitative evaluation of the introduction of economic valuation in the framework. We will show separate results for the domestic and irrigation sectors. These results show that we obtain more sensible results in terms of demand satisfaction when economic rules are used than without economic rules: with economic rules the satisfaction of domestic demand increases to the detriment of irrigation demand, and the demand satisfaction rates obtained are closer to expected figures (except for 1 basin, where domestic demand satisfaction is unexpectedly low).

For further details, please also see our replies to Anonymous Referee #1 comments: comment #4.

—

Details:

Thank you for the suggested corrections, we will take all of them into account. Please see below our answers to some specific comments.

3. "P3L1: It is not clear what is meant with "mostly quantitative" here. Why is this a limitation of such studies?"

> The sentence will be rephrased. We meant that these studies focus on the quantity of water, without incorporating an economic assessment (no economic value of water, only quantities).

7. "Figure 7 should be much improved. Make an inset map showing the location of the area on the planet. Put a scale/coordinate system. Maybe use elevation model as background."

> Figure 7 will be improved as suggested. We will keep the map in grayscale, as the aim of using grayscale is to improve accessibility for colour-blind readers.

8. "I believe figs 3 and 4 can be combined into one. Also, from the discussion given in appendix B, it seems that the demand functions should be piecewise horizontal, not piecewise linear."

> Figures 3 and 4 will be combined.

> The domestic demand function is piecewise linear, with slopes (Cf. text in Appendix B and Figures). You may have been thinking of piecewise horizontal because of section 4.2: In this section, we explain how projected demands are broken down and grouped into classes based on their value. So the domestic demand function is piecewise linear, but then projected demands are discretized to ease operating rules determination, at the cost of using an approximation of the domestic demand function value.

—

References:

Dubois, C. et al. (2012) Future projections of the surface heat and water budgets of the Mediterranean Sea in an ensemble of coupled atmosphere–ocean regional climate models. Climate Dynamics (39).

Nassopoulos, H. and Dumas, P. (under revision) Reconstructing river basin anthropogenic networks with a global coverage: A validation on Algeria.

Neverre, N. and Dumas, P. (2016) Projecting Basin-Scale Distributed Irrigation and Domestic Water Demands and Values: A Generic Method for Large-Scale Modeling. Water Economics and Policy, Vol. 2, No. 3.

Pérennès, J-J. (1993) L’eau et les hommes au Maghreb. Contribution à une politique de l’eau en Méditerranée. Paris, Karthala. pp. 646.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., doi:10.5194/hess-2015-502, 2016.