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Discussions

Interactive comment on "A dynamic water accounting framework based on marginal resource opportunity cost" *by* A. Tilmant et al.

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The authors would like to thank the reviewer for his/her constructive comments. Our detailed responses to the comments and the proposed changes/corrections are given below.

1)I understand that an optimization-based model can simultaneously solve for allocations and marginal costs (page 11741, line 9-10), but why are simulation-based methods much more computationally demanding, especially in large networks? It makes sense to use an optimization method here, because the goal is to maximize the economic benefits in the system, but for a different objective, such as evaluating the change in economic benefits under certain operational rules, wouldn't simulation-

based methods better accommodate potential if-else rules which sometimes exist in the real world? When would these computational challenges begin to overtake the benefits of flexibility which exist with simulation-based methods?

To obtain the MROC for each time step and for various states of the system, one would need a large number of simulations. We agree with you that simulation-based hydro-eco models offer some advantages regarding the level of details. But since the optimization-based model was already available, and we did not need to model more processes, we choose the optimization approach instead. It is important to stress that the accounting framework is generic and not attached to a particular hydro-economic formulation as long as the allocation decisions and MROC are available. Hence, our choice is not dogmatic but rather pragmatic.

2) In the 'optimal' solution (i.e. maximizing economic benefits) provided by the SDDP algorithm, are the MROC prices at each node the same for a given time-step? This seems to be the solution given my understanding of the theory, as well as what is suggested via equations 7-9. From those equations, if the MROC price was higher at node 2, it would suggest the RBA would want to 'buy' more spillage from reservoir 1 so they could 'sell' more water to reservoir 2. If this is the case, it might be worth mentioning somewhere in the text. If it is not the case, the authors should address the reasons that the results do not correspond to intuition here.

Here, the MROC are not identical because we have a cascade of hydropower plants (essentially non-consumptive and non-rival use of water). The aggregation of demand curves for non-rival uses yields increasing MROC as we move to the upstream nodes because the curves are summed up vertically (they are summed up horizontally for rival uses like irrigation). The aggregation is done automatically in the hydro-economic model. In other words, a water manager would be willing to pay more to get an additional unit of water upstream because that unit will be used several times and generate value as it flows to the sea. The MROC also vary in time because the availability of water during the high flow and the low flow season is different. Note that this effect is mitigated with the large reservoirs. Eq (7) is obtained by multiplying both sides of eq (6) by the MROC at that site (i.e. site 1). Provided that the reservoir 1 does not spill, the MROC at site 1 should be larger than that at site 2 (downstream) because there is a power plant between both sites (hpp1). Since that power plant is a non-rival use, the willingness to pay for an additional unit of water at site 1 (upstream) is larger than at site 2 (downstream). If the reservoir spills, and provided there is no penalty when spilling, then MROC1 = MROC2: getting one more unit of water at site 1 does not increase the total benefits.

3) I found the inclusion of the 'RBA' to be an interesting part of this analysis. It seems to be a necessary artifact of the accounting method to allow for different prices at different nodes during the same timestep, but it is suggested that the RBA would serve some real-world service in coordinating efficient economic decisions within the basin. It would be interesting to see some further discussion of this potential role of economic incentives for the RBA. Would a strictly profit-seeking motive for the RBA be enough to encourage more efficient decisions within the basin? Or would the purchase/selling prices for the RBA need to be regulated in some way?

This is an interesting comment. In this exercise, the mandate assigned to RBA is fairly traditional: maintain the hydrologic integrity of the basin, coordinate allocation policies, etc. The presence of RBA also signals the value of the hydrological services in the watershed responsible for blue water flows. We made the assumption that the coordination would be achieved through the maximization of basin-wide benefits, something that can be relaxed by implementing the hydro-economic mode sequentially or by imposing additional constraints. Scenarios of institutional arrangements could be analyzed but it is beyond the scope of the present study.

4) In the paragraph starting on page 11750, line 9, the irrigation schemes are referred to as having an 'opportunity cost', while other uses of water are referred to as having 'value'. Is this because the value of that irrigation is less than the MROC of the water at that node? If the basin wide allocations are economically efficient (an assumption

explicitly made in the paper), shouldn't the algorithm allocate less water to irrigation?

Irrigation withdrawals are considered as benefits forgone because irrigated agriculture is a rival use: each unit of water is no longer available for the downstream users, therefore having an opportunity cost. When the allocation decisions are economically efficient, the marginal value of irrigation water at site "j" should be equal to its marginal opportunity cost. If the marginal value were > than the marginal opp cost, then more water should be allocated to the irrigation scheme. Similarly, if the marginal value were < than the marginal opp cost, then less water should be allocated to the irrigation scheme. Hence, at the optimal solution, both marginal quantities (opp cost and value) should be equal. When an irrigation withdrawal is multiplied by the associated marginal value (or opp cost), the product corresponds to both the value of irrigation water and the opportunity cost of that water. It is like the two faces to the same coin.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 11, 11735, 2014.