Interactive comment on “Determination of cost coefficients of priority-based water allocation linear programming model – a network flow approach” by F. N.-F. Chou and C.-W. Wu

Anonymous Referee #1
Received and published: 28 January 2014

Chou and Wu present a compelling description of how to set up a network flow programming approach. Modeling complex water resource systems is a challenge in and of itself, but if one includes multiple users with varying allocation priorities it can become a nearly impossible task. Overall, I think Chou and Wu make an important and practical contribution to the literature.

Their work does raise one important question as to what information can be gleaned from the calculated cost coefficients. Let us imagine a complex system with many users who have priority-based allocations of water (i.e., the prior-appropriation system of water rights that is commonly used in the western United States). What can the magnitude of a cost coefficient for an individual water right say about the value of that water right relative to other water rights? More specifically, let us assume a municipality wishes to purchase a water right. The municipality enters negotiations with a number of current water right owners who may be interested in selling. The water rights of the current owners have varying allocation priorities, withdrawal locations, and asking prices. Might an NFP approach that calculates cost coefficients might also inform the municipality as to the relative value of each water right? Combined with the price of each water right, could the cost coefficients indicate to the municipality which water right is the best deal?

As to criticism/suggestion of the paper, I have only one significant suggestion. The equations in the paper are grounded in linear algebra and set theory, as they should be. But for those of us less practiced in them, these formulations can be hard to follow. The authors kindly included Appendix A, which explains Krofts enumeration algorithm. Other appendices that lay out the algorithms for the various water allocation rules (using their study region as an example, perhaps) might expand not only the readership of this paper, but also the application of its techniques. If the authors would be willing to add such appendices, I think the paper would greatly benefit from it.

All in all, a good paper. (Please note that I only marked the figures as "Good" as their resolution was pretty poor on my end, but I’m sure that’s not the problem with the originals.)

The authors' response

First of all, we wish to express our sincere appreciation for the review and comments offered by both Anonymous Referees. At the suggestion of the first reviewer, an appendix has been added to the revised manuscript. It presents an example simplified from the case study section to demonstrate how the linear programming formulation is established by the proposed method. The linear inequalities converted from different allocation rules are presented in order to clarify for more readers how the proposed method might be applied to their own applications.

As for the economic implications of the calculated coefficients, we prefer to treat these values purely as priority weighting factors for efficient water allocation analysis only. Since the applied model belongs to the descriptive simulation category, the expected economic benefits and costs of a specific allocation strategy can be calculated post simulation. The most beneficial strategy can be obtained by either testing the performances of different proposed strategies through different simulation runs involving only priority-based water allocation, or linking the simulation model to another optimization algorithm to calibrate the optimal strategy.

Last but not least, all figures have been re-uploaded to provide sufficient resolution with reasonable file size in the revised manuscript.

With best regards,
Frederick N.F. Chou and Chia-Wen Wu

Interactive comment on "Determination of cost coefficients of priority-based water allocation linear programming model – a network flow approach" by F. N.-F. Chou and C.-W. Wu

Anonymous Referee #2
Received and published: 28 January 2014

This is a nice application and extension of the earlier paper by Israel and Lund 1999. I like the authors' greater formalism from the earlier paper. Earlier work by Israel and Lund 1999 and a later 2007 dissertation by Ines Ferreira ("Deriving Unit Cost Coefficients for Linear Programming-Driven Priority-Based Simulation") implicitly consider all flow paths in their work and note many of the aspects developed in this newer paper.

The Ferreira dissertation is available at http://cee.engr.ucdavis.edu/faculty/lund/students/FerreiraDissertation.pdf and broadens the scope of the topic to include cost coefficient setting for more general linear programming formulations. There is a small application to the CALSIM model of California's water system. Linear programming has replaced network flow programming for many priority-based simulation software applications.

Some updating of the literature review, greater noting of the lineage of the authors' approach, and extending the discussion somewhat to include comments on LP-based simulation as opposed to only NFP-based simulation would improve the paper.

I am glad to see others address this interesting problem for priority-based simulation models that uses an optimization engine.

The authors' response

We sincerely appreciate the suggestions given by the second Anonymous Referee, from which this paper benefits greatly.

This study indeed was inspired by the paper of Israel and Lund (1999) and the subsequent discussion by Labadie and Baldo (2001), which represent two counterparts of priority-based water allocation using optimization engines. While network flow programming (NFP) possesses the advantages of higher computing efficiency and easier comprehension of the priority-based allocation mechanism, linear programming (LP) can directly incorporate side constraints in the formulation to prevent the need for iterations commonly required in NFP models. Nonetheless, the priorities in LP-based models may be impaired due to the influence of side constraints, thus necessitating special consideration when establishing the objective function of the LP formulation. Conversely, NFP-based models are free of side constraints, thus simplifying the task of assigning cost coefficients.

Our position with respect to the present study recognizes the respective benefits of both LP and NFP models. While this research utilizes an NFP model, we also find situations when assigning cost coefficients can be complex and challenging, especially when trans-basin surplus water diversion and storage allocation among multiple reservoirs are involved. This scenario is where this study originates.

According to the reviewer's suggestions, the manuscript has been revised as follows:

1. The Introduction concludes with greater detail pertaining to the lineage of this study.
2. Our opinion regarding the NFP- and LP-based water allocation models is given in the "Alternative approaches: linear programming versus network flow programming" sub-section.
3. In addition to Ferreira (2007), four other articles associated with LP-based allocation models have been added in the references.

With best regards,
Frederick N.F. Chou and Chia-Wen Wu