Hydrol. Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/hess-2017-107-AC1, 2017

Hydrology and Earth System Sciences
Discussions
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Interactive comment on "Socio-hydrology from the bottom up: A template for agent-based modeling in irrigation systems" *by* Dimitrios Bouziotas and Maurits Ertsen

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Received and published: 11 June 2017

We would like to thank the reviewer for the supportive attitude towards our paper. We appreciate the constructive criticism and remarks on the purpose, clarity and contribution of this work. What we hope to contribute to socio-hydrology in a fundamental way is a perspective not commonly seen in modeling studies: a modeling philosophy plus proof of concept in which social agency play a major role and a model that is built upon the agents' signal-based perceptions of (and actions towards) the hydrological reality. This was demonstrated precisely by constructing an ABM based on signals – which we detail further in our general comments. The Irrigation Management Game, from which

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the ABM was based, provided a serious gaming application to a particular realm that is directly related to real-word irrigation systems, given in a level of abstraction and simplicity that helps the readers understand the core ABM mechanics without being lost in too much real-word complexity. At the same time, the IMG is an environment in which agent actions, decisions and experience feedbacks form the heart of the gaming experience, thus emphasizing the social aspects within a socio-hydrological system. We therefore assessed that this could be a prime case where our bottom-up, agent-based proof of concept could be based upon.

The purpose of our signal-based ABM was to develop a modelling methodology that allows to study agent actions, their possible effects for other agents, and possible results in terms of water distribution, crop growth and wealth creation – as these are parameters relevant for our immediate serious game environment and for socio-hydrological systems in general.

We agree that the emerging (up-scaled) effects from our ABM are not so much found in a community response. We do observe emergent effects though, as we show that within the IMG-ABM the series of decisions that are made by the agents create global patterns well-known in gravity irrigation in general and the IMG in particular. The general dynamics that were discussed in previous settings are apparent; upstream users generate more financial revenue and use more water, whereas downstream users generate less revenue, but generally more revenue per unit of water. We agree, however, that some of the claims on emergence need to be nuanced, and we aim to clarify our position on and examples of emerging effects in an updated version of our work.

We are not certain about the reviewer's comment that we should highlight the "social" factors of the socio-hydrology of our system. As described above, we believe the modelling philosophy and agent-oriented, signal-based logic offers a significantly improved view and schematization of social interactions compared to many previous works. We have given focus on human actions in a water system, which create new properties of the water system itself; the cascading effects seen in the system output

and other agents downstream is an important social and socio-hydrological mechanism. It is indeed correct that we did not include elements or properties of higher-order social relations yet, which may have created the feeling of underwhelming model results. However, we wanted to discuss our signal-based concept and general approach first before moving to further refinements. Moreover, we feel that more complex social interactions, such as scenarios of changing norms and values, will over-parameterize a simple modelling layout at this proof-of-concept stage. We believe that adhering to simplicity at this stage is needed, since the coupling with the real IMG is loose (i.e. the real gaming setting is not optimized to provide a detailed database to study, develop and calibrate the digital template) and thus we can only observe general mechanisms and dynamics and record simple agent interaction from real game settings. We believe a stronger coupling with an updated version of the real gaming environment could indeed allow the study of higher level social interactions between agents. If desirable, we can include our elaboration and ideas on how that could be done – and the evident social data needs from future versions of the IMG.

We do not think that our critique of lumped, top-down approaches can be easily met once we have additional and more appropriate observations. This is indeed closely related to a philosophical point of view of how societies and social relations are built and how they can be studied. We have not included much on this, as our position is discussed in other papers (especially by the second author), but we could clarify our position better in this HESS contribution.

Given these comments, we do not agree that this work pays lip service to how ABM can increase our understanding within socio-hydrology. We would argue that our first modelling efforts represent a rather important different perspective to building socio-hydrological models, where human agency is modeled at the individual scale and social interactions are more clear – and thus, better mapped and modeled - than in the case of observing and modeling lumped societal behaviour. We agree that we provide limited results, but would argue that these results – the core dynamics of irrigation networks,

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reflected through a simple structure - provide clear evidence of the promising nature of our concept. It is obvious that we need to improve the presentation of and focus to our argument – for which we further propose ideas, not only in this answer but also to our general comments.

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